Guess Who, Gumshoe?

From the Case Files of the Effective Detective

Samples of Possible Common Core and TN Academic Standards to Incorporate:

As you read the activities, keep in mind the specifics skills your students need to practice and master in the different grade levels and use them to guide your approach in how you present the activities and what you have the students do. We encourage you to add additional SPIs and Academic Vocabulary in your plans that are outside the specific ones listed below as there are many which apply and are not listed below.

Kindergarten:

- 7.9.2 Observe, discuss, and compare characteristics of various solids and liquids.
- 7.T/E.1 Explain how simple tools are used to extend the senses, make life easier, and solve everyday problems.
- K.MD.2. Directly compare two objects with a measurable attribute in common, to see which object has "more of"/"less of" the attribute, and describe the difference.
- K.MD.1. Describe measurable attributes of objects, such as length or weight. Describe several measurable attributes of a single object.
- K.3.01 Understand how to use maps, globes, and other geographic representations, tools, and technologies to acquire, process and report information from a spatial perspective.
    a. Explain what a globe and map represent.
    b. Use personal directions such as up, down, left, right, near and far to describe relative direction.
- K.3.03 Demonstrate how to identify and locate major physical and political features on globes and maps.

1st Grade:

- 7.9.2 Compare liquids according to their color, ability to flow, solubility in water, and use.
- 7.11.1 Use familiar objects to explore how the movement can be changed.
- 7.T/E.1 Explain how simple tools are used to extend the senses, make life easier, and solve everyday problems.
- RL.1.4. Identify words and phrases in stories or poems that suggest feelings or appeal to the senses.
- 1.MD.2. Express the length of an object as a whole number of length units, by laying multiple copies of a shorter object (the length unit) end to end; understand that the length measurement of an object is the number of same-size length units that span it with no gaps or overlaps.
- L.1.5. With guidance and support from adults, demonstrate understanding of figurative language, word relationships and nuances in word meanings.
- 1.3.01 Understand how to use maps, globes, and other geographic representations, tools, and technologies to acquire, process and report information from a spatial perspective.
    a. Recognize that maps and globes are representations or models of specific places.

c. Use map symbols and legends to identify locations and directions.

d. Interpret symbols that represent various forms of geographic data and use these symbols to identify locations and directions.

- 1.3.02 Recognize how to identify and locate major physical and political features on maps and globes.

  a. Define what cardinal directions are (N,S,E,W)

  b. Locate places using cardinal directions on maps and globes.

  c. Locate cities, states, countries, and continents on maps and globes and major bodies of water on maps and globes.

  f. Identify the geographic location of the United States on a globe and a map.

2nd Grade:

- 7.9.1 Use tools such as hand lenses, measurement devices, etc. to gather data about the physical properties of different objects.
- 7.T/E.1 Explain how simple tools are used to extend the senses, make life easier, and solve everyday problems.
- 2.MD.1. Measure the length of an object by selecting and using appropriate tools such as rulers, yardsticks, meter sticks, and measuring tapes.
- 2.MD.2. Measure the length of an object twice, using length units of different lengths for the two measurements; describe how the two measurements relate to the size of the unit chosen.
- W.2.5. With guidance and support from adults and peers, focus on a topic and strengthen writing as needed by revising and editing.
- 2.MD.4. Measure to determine how much longer one object is than another, expressing the length difference in terms of a standard length unit.
- RI.2.3. Describe the connection between a series of historical events, scientific ideas or concepts.
- L.2.5. Demonstrate understanding of figurative language, word relationships and identify real-life connections between words and their use
- 2.3.01 Understand how to use maps, globes, and other geographic representations, tools, and technologies to acquire, process and report information from a spatial perspective.

  d. Recognize that a map contains elements such as title, scale, symbols, legends, grids, cardinal and intermediate direction."
- 2.3.03 Demonstrate how to identify and locate major physical and political features on globes and maps.
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3rd Grade:

- SPI 7.11.1 Identify how the direction of a moving object is changed by an applied force.
- SPI 7.9.1 Describe a substance in terms of its physical properties.
- 7.T/E.1 Explain how different inventions and technologies impact people and other living organisms.
- L.3.3. Use knowledge of language and its conventions when writing, speaking, reading, or listening. Choose words and phrases for effect.

- W.3.5. With guidance and support from peers and adults, develop and strengthen writing as needed by planning, revising, and editing.
- SPI 7.T/E.1 Select a tool, technology, or invention that was used to solve a human problem.
- 3.3.01 Understand how to use maps, globes, and other geographic representations, tools, and technologies to acquire, process and report information from a spatial perspective.
    c. Locate places on a map using cardinal and intermediate direction.
- 3.3.02 Recognize the interaction between human and physical systems around the world.
- 3.3.03 Demonstrate how to identify and locate major physical and political features on globes and maps.

4th Grade:

- 7.11.2 Design an investigation to identify factors that affect the speed and distance traveled by an object in motion.
- SPI 7.11.2 Identify factors that influence the motion of an object.
- 7.9.1 Use appropriate tools to measure and compare the physical properties of various solids and liquids.
- RI.4.3. Explain events, procedures, ideas, or concepts in a historical, scientific, or technical context, including what happened and why.
- L.4.3. Use knowledge of language and its conventions when writing, speaking, reading, or listening. Choose words and phrases to convey ideas precisely and choose punctuation for effect.
- W.4.7. Conduct/participate in short research projects that build knowledge through investigation of different aspects of a topic.
- 4.3.01 Understand how to use maps, globes, and other geographic representations, tools, and technologies to acquire, process and report information from a spatial perspective.
    a. Locate major countries of the world on a map or globe…
    b. Locate places on a map using cardinal and intermediate directions, latitude and longitude, and time zones.
- 4.3.03 Understand how to identify and locate major physical and political features on globes and maps.

5th Grade:

- SPI 7.T/E.2 Recognize the connection between a scientific advance and the development of a new tool or technology.
- 7.T/E.1 Explain how different inventions and technologies impact people and other living organisms.
- 7.10.5 Demonstrate different ways that energy can be transferred from one object to another.
- W.5.5. With guidance and support from peers and adults, develop and strengthen writing as needed by planning, revising, editing, rewriting, or trying a new approach.
- L.5.3. Use knowledge of language and its conventions when writing, speaking, reading, or listening. Expand, combine, and reduce sentences for meaning, reader/listener interest, and style. Compare and contrast the varieties of English used in stories or poems.

- W.5.7. Conduct/participate in short research projects that use several sources to build knowledge through investigation of different aspects of a topic.
- 5.3.01 Understand how to use maps, globes, and other geographic representations, tools, and technologies to acquire, process and report information from a spatial perspective.
- 5.3.02 Recognize the interaction between human and physical systems around the world.
- 5.3.03 Demonstrate how to identify and locate major physical and political features on globes and maps.

6th Grade:

- SPI 7.T/E.1 Identify the tools and procedures needed to test the design features of a prototype.
- RI.6.7. Integrate information presented and gained through different media or formats (e.g., visually, quantitatively, kinesthetically) as well as in words to develop a coherent understanding of a topic.
- 7.T/E.5 Develop an adaptive design and test its effectiveness.
- 6.3.01 Understand the characteristics and uses of maps.
    a. Use the basic elements of maps and mapping.
    b. Identify the locations of certain physical and human features and events on maps and globes.
- 6.3.02 Know the location of places and geographic features, both physical and human.

7th Grade:

- 7.11.4 Recognize how a net force impacts an object's motion.
- 7.T/E.5 Develop an adaptive design and test its effectiveness.
- L.7.2. Demonstrate command of the conventions of standard English capitalization, punctuation, and spelling when writing.
- 7.T/E.2 Apply the engineering design process to construct a prototype that meets certain specifications.
- 7.3.01 Understand the characteristics and uses of maps, globes, and other geographic tools and technologies.
    a. Identify, describe, and be able to use the basic elements of maps and mapping.
    b. Identify the location of physical and human attributes on maps and globes at local, regional, and/or global scales.
- 7.3.02 Know the location of places and geographic features, both physical and human, locally, regionally and globally.
- 7.3.03 Understand the characteristics and uses of spatial organization of Earth's surface.
- 7.3.04 Understand the physical and human characteristics of place on a map or globe.

8th Grade:

- 7.T/E.5 Develop an adaptive design and test its effectiveness.
- 7.T/E.1 Use appropriate tools to test for strength, hardness, and flexibility of materials.
- 7.9.3 Measure or calculate the mass, volume, and temperature of a given substance.
- 7.9.2 Illustrate the particle arrangement and type of motion associated with different states of matter.

- W.8.7. Conduct short research projects to answer a question (including a self-generated question), drawing on several sources and generating additional related, focused questions that allow for multiple avenues of exploration.
- RST.6-8.9. Compare and contrast the information gained from experiments, simulations, video, or multimedia sources with that gained from a text on the same topic.
- 8.3.01 Understand how to use maps, globes, and other geographic representations, tools, and technologies to acquire, process, and report information from a spatial perspective.
    a. Locate major countries and regions of the world on a map or globe.

High School

- 1.1.15 Relate inertia, force, or action-reaction forces to Newton's three laws of motion.
- 1.Inq.1 Trace the historical development of a scientific principle or theory.
- 6.2 Understand psychological concepts, methods and theories in analyzing how humans think learn, feel and behave.
- W.11-12.3 Use a variety of techniques to sequence events so that they build on one another to create a coherent whole and build toward a particular tone and outcome (e.g., a sense of mystery, suspense, growth, or resolution).
- RL.9-10.5. Analyze how an author's choices concerning how to structure a text, order events within it (e.g., parallel plots), and manipulate time (e.g., pacing, flashbacks) create such effects as mystery, tension, or surprise.
- W.9-10.5. Develop and strengthen writing as needed by planning, revising, editing, rewriting, or trying a new approach, focusing on addressing what is most significant for a specific purpose and audience.
- L.9-10.5. Demonstrate understanding of figurative language, word relationships, and nuances in word meanings.
- 3.1 understand the characteristics and uses of maps, globes, and other geographic tools and technologies and construct maps and other geographic representations using primary data.
- 3.2 know the location of places, geographic features, and patterns of the environment, both physical and human, locally, regionally, and globally.
- 3.3 Understand the characteristics and uses of spatial organization of Earth's surface.
- 4.5 Understand the role of the United States legal system.

Samples of Possible Academic Vocabulary to Incorporate:

For the Academic Vocabulary we encourage you to use as many of these words as possible, not simply pick one or two. The more words we can introduce in a setting that makes sense to our students, the better.

Kindergarten:

- Solid/liquid
- Pattern
- Tools
- Natural
- Compare
- Contrast
- Human
- Honesty

- Map
- Globe

1st Grade

- Sequence
- Predict
- Property
- Investigate
- History
- Past
- Present
- Future

2nd Grade

- Energy
- Investigate
- Observation
- Similarities/Differences
- Pre-write
- Draft
- Edit

3rd Grade

- Force
- Tools
- Cause
- Effect
- Punctuation
- Verb

4th Grade

- Probability
- Proofread
- Prediction
- Compare
- Contrast

5th Grade

- Theme
- Punctuation marks
- Formula

6th Grade

- Cause and Effect
- Criteria
- Similarity
- Simulation

7th Grade

- Impact
- Interaction with texts
- Property
- Mood
- Genetic characteristic
- Function

8th Grade

- Inductive & Deductive Reasoning
- Sequence
- Human Impact
- Reasoning
- Vernacular
- Mood/tone
- Revision

FILE NO. 45780B

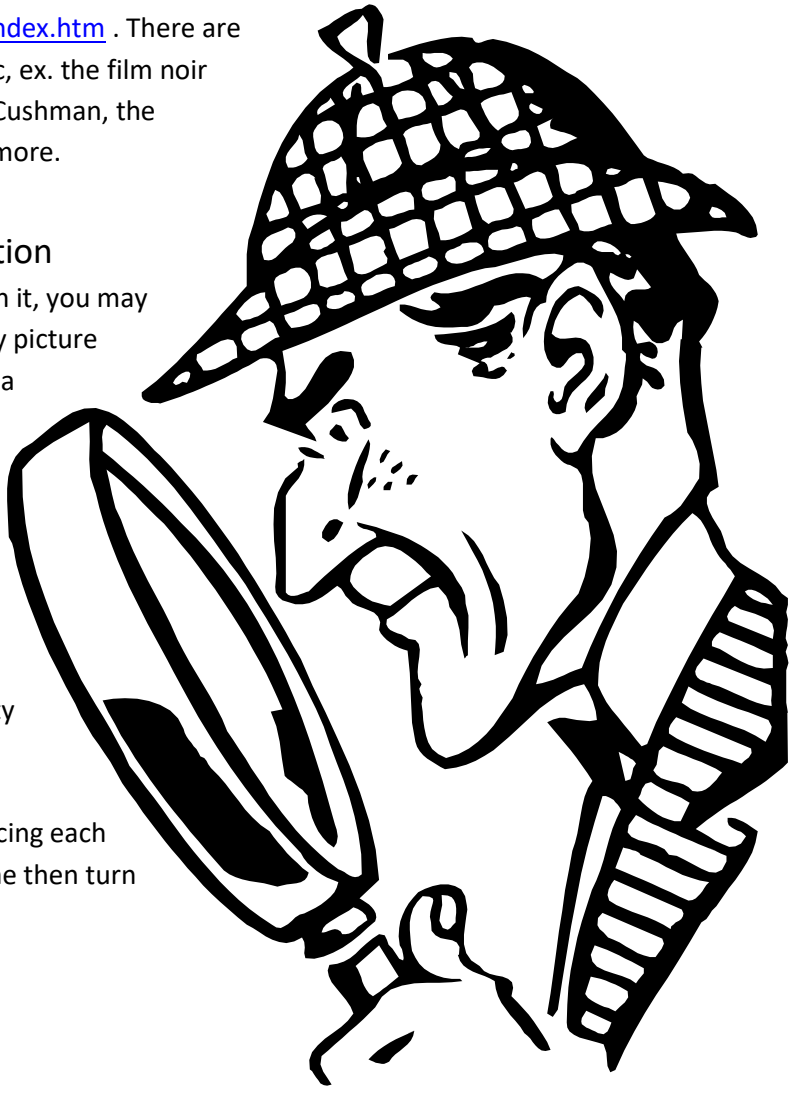
Guess Who, Gumshoe?

From the Case Files of the Effective Detective

"I never guess. It is a shocking habit—destructive to the logical faculty. What seems strange to you is only so because you do not follow my train of thought or observe the small facts upon which large inferences may depend." --Sherlock Holmes, *The Sign of Four*

Gumshoe: noun. An old slang term for a detective or investigator (police-affiliated or private). Shoes in the late 1800s were made of gum rubber - the soft-soled precursors of the modern sneaker. The phrase "to gumshoe" meant to sneak around quietly and stealthily, as if wearing gumshoes. By about 1908 the term "gumshoe" was used to refer to a police detective, and the term has stuck ever since (pun intended). Intransitive Verb Form: gumshoeing

Introduce the lesson and the importance of careful observation in detective work, and the distinction between "seeing" and "observing" by choosing some riddles that have unexpected, but logical solutions from a book, ex. *Picture Puzzles for Armchair Detectives* by Doug Anderson, or other activities such as the Math Maven puzzles at http://teacher.scholastic.com/maven/cafeteri/index.htm . There are many excellent picture books based on this topic, ex. the film noir inspired *Mystery at the Club Sandwich* by Doug Cushman, the hilarious *Grandpa's Teeth* by Rod Clement, and more.



Activity: Practicing the Art of Observation

Show the kids a picture that has a lot of details in it, you may choose the cover of a kids mystery book, but any picture with a lot of detail will do. Give the group about a minute to look at the picture, encouraging them to make a mental note of as much as they can, including small details that they think others will overlook. When the time is up, put the picture away and get the kids to call out what they saw, and write them down on a whiteboard or flipchart. See how long you can make the list of things observed. This activity gets everyone participating.

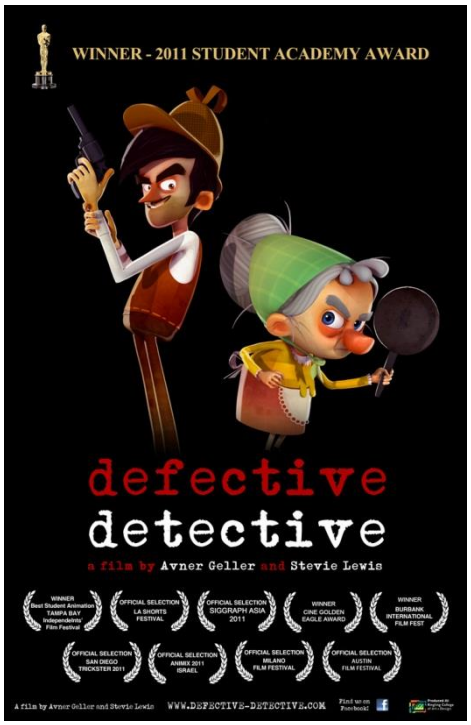
Variations:

- Have students form two lines of pairs facing each other for 30 seconds. Students in one line then turn

away, and the students in the other line change one thing about their appearance (for example, untie shoe, remove earring, flip hair). The students in the first line then turn back and determine what is different.

- Allow students to test your powers of observation by you closing your eyes while they change ONE thing about themselves, ex. two students exchange seats, put chin on hand, etc.
- Someone runs quickly (and without warning) through the room. Students describe the individual.

From this observation practice, guide students to begin to note how different people remember an event or a movie. Show a short movie clip lasting three to five minutes, such as The Defective Detective, a humorous and Academy Award winning short film by Avner Geller and Stevie Lewis http://vimeo.com/25541923, http://www.cartoonbrew.com/brewtv/detective-45212.html, or https://www.youtube.com/watch?v=tiy1MeXzhfA. Or stage a short event for students. After they watch the clip or see the event, question the students individually about what they saw and heard during the clip. Ex. What is the first sound you hear when the video starts? How many windows were lit in the building? What is the detective's name? What substance plopped down on his newspaper? What did the detective think it was? Analyze their answers for patterns and keep track of responses on the board. Did more women remember a particular part than men? Were there differences in recall based on age? Did the viewer's placement in the room change how they saw the event? Have students draw conclusions about the reliability of eyewitness testimony from this experiment. **Then, have students watch it again and discuss what they noticed the second time that they didn't notice before.**



The Invisible Gorilla

To further test their observational skills and see what they've learned have students watch the following video… http://www.theinvisiblegorilla.com/gorilla_experiment.html and ONLY tell them they must keep a silent count of the number of passes made by the people in white shirts and that you will see how many got the correct count at the end of the video. Note: At some point, a gorilla strolls into the middle of the action, faces the camera and thumps its chest, and then leaves, spending nine seconds on screen. Will they see the gorilla? Will you? **If they didn't, why did they miss it? What does this teach us about our powers of observation?** This experiment reveals two things: that we are missing a lot of what goes on around us, and that we have no idea that we are missing so much.

Map it Out

For the following discussion you will want to display a globe or world map for students to locate and mark the following forensic history locations as you study them by placing the forensic icon (printable sheet included), on the appropriate location with the Who, What, Where, & When filled out.

For a more hands on/hands in method of introducing students to the world map & identifying country locations go to:

http://education.nationalgeographic.com/education/multimedia/world-political-mapmaker-kit/?ar_a=1

Download, print, and have students assemble a map of the political world in one of a variety of sizes. *For visual and audio learners: Watch the tutorial video at the website above to get started.* These maps are reusable for projects in the future.

Option: Have students create a timeline with the following facts, how long does their timeline need to be? Will they go all the way from 40sBCE to 2000 AD in single years?

Where it all began…

As you conduct the following discussion, have students read along, listen for information, and fill in the missing details on their own student timeline sheets.

Incorporate the map and included clue sheets as an active part of your discussion by having students work together to identify and locate the different countries, identify WHO did it, WHAT they did, WHERE they were located, WHEN it happened and mark the appropriate places where forensics took place with the forensic symbol [the magnifying glass & fingerprints] and information.

To facilitate the activity, the list of 18 may be divided into sections and students can be assigned different numbers, ex. the first three, to locate, identify, and mark, with the class discussing the map as a whole and what students observe (ex. which country or countries have had the most advances in forensic science, which time periods had the most advances) once all locations have been marked on the map.

To be an effective detective, we need to be observant and we need to know how it all began, and that doesn't just mean, "It was a dark and stormy night…" The history of forensic science dates back thousands of years and fingerprinting was one of its first applications. The ancient Chinese used

fingerprints as signatures to identify business documents. So, let's follow the trail of clues from their beginning and who knows, maybe it was a dark and stormy night when…

- In 40s BCE, Antistius, a Roman physician in Rome, Italy performs the first recorded autopsy (an examination on a body after death to see what happened), on the body of Julius Caesar.
- In the 1240s Song Ci, a presiding judge in the criminal courts in China uses his own experience investigating murders to write the first forensic science textbook. He describes one case in which a judge solved a murder by taking all the tools in a village and determining that only one of them attracted flies, which he attributed to the scent of blood
- In the 1540s Dr. Ambroise Paré, a French army surgeon carefully studied the effect of violent death upon human internal organs. His work is the beginning of modern forensic pathology (the branch of medical science that uses medical knowledge for legal purposes).
- In Lancaster, England in the 1780's a surgeon removes a piece of pistol wad — crushed paper used to secure gunpowder and balls in a weapon's muzzle (the open circular end of a gun where the bullet comes out) — from the fatal head wound of a shooting victim. Investigators find that the paper matches a torn newspaper in the pocket of suspect John Toms, who is convicted of murder.
- In the 1820s, in France the detective Eugène François Vidocq pioneers the use of ballistics (studying the effect of being fired on a gun or a bullet) and makes plaster casts of shoe impressions to solve crimes.
- In 1830, in England when an Englishman is put on trial for allegedly murdering his grandfather by tampering with his coffee, chemist James Marsh used scientific methods to identify arsenic poisoning as the probable cause of death. A skeptical jury didn't believe his evidence or the test and said that it didn't prove the person was guilty, so they set him free. Marsh is so annoyed by this that he invents a new process, the Marsh test, which is so sensitive that it can detect as little as 0.02 of a gram of the poison.
- In 1835, in England Scotland Yard's effective detective Henry Goddard became the first person to use physical analysis to connect a bullet to the murder weapon.
- In the 1880s in England, police constable Major L.W. Atcherley develops the concept of modus operandi ("method of operation"), in which information from different crime scenes is used to make connections and establish a pattern of behavior that shows the same person or people did all of the crimes.
- In 1892 Sir Edward Henry, inspector general of the Bengal Police in India and head of the Metropolitan Police of London built his own system for fingerprinting based on the direction, flow, pattern and other characteristics in fingerprints. Our modern systems are still based on it.
- Leone Lattes in Italy in 1910 develops a method for determining the blood type of even a dried bloodstain.

- Edmond Locard, a professor at the University of Lyons in France in 1910 discovered a need for a specialized team to analyze evidence found at crime scenes. To that end, Locard set up the first police crime laboratory in France in 1910.
- Dr. Calvin Goddard a physician and expert in firearms identification in the 1920's in Chicago after the St. Valentine's Day Massacre, in which seven underlings of Chicago mobster George "Bugs" Moran are arrested and then machine-gunned by what appear to be five Chicago police officers, is called in to investigate. Goddard uses the recently developed comparison microscope to compare shell casings (empty packets that went around the bullets) from the scene with samples fired by the police department's Thompson machine guns. None match, indicating that the assassins were impersonators (people pretending to be cops), rather than actual cops. The real police eventually raid the home of a hit man employed by Moran rival Al "Scarface" Capone, where they find two of the weapons used in the murder and when they were tested, they found a match!
- In 1930 Scientist Karl Landsteiner of Austria wins the Nobel Prize for classifying human blood into its various groups. His work paved the way for the future use of blood in criminal investigations..
- In the 1950s Canadian crime lab investigators use a process developed two decades earlier to measure the concentration of elements in a material. The test shows that hairs found near a female murder victim are consistent with those of an American suspect, John Vollman. After the hair and other scientific evidence is presented at trial, Vollman pleads guilty to murder.
- In the 1960s, the FBI and the National Bureau of Standards in Washington, DC develop the first computerized fingerprint database, which eventually will enable investigators to compare prints lifted from a crime scene to millions of records on file and generate possible matches in a matter of seconds.
- In 1972, William Bass III establishes the University of Tennessee Forensic Anthropology Facility, aka "The Body Farm," outside Knoxville, TN. The purpose is to advance the scientific study of postmortem decay and skeletal remains. Knowledge gained at the center serves both a law enforcement function and a methodical contribution to the knowledge about the human body. He and other researchers will leave hundreds of corpses (that were donated to science) lying in the sun (up to 40+ in the farm at a time), buried at various depths and in varying soil conditions, and submerged underwater to study their decomposition. The data learned enables investigators to perfect techniques for locating bodies, and to more accurately estimate the time of death.
- In the 1990s, the FBI in Washington, DC start to build its Combined DNA Index System (CODIS), the first computerized nationwide system for matching DNA samples from suspects with those collected from crime scenes.
- In 2000s Neil McMurray and Geraint Williams of Swansea University in England, develop a method for finding prints left by natural oils from the skin without the use of fingerprint powder. The new process is so good, it can reportedly even raise prints even on objects that have been wiped clean.

Timeline

Date	What happened?

What did I do? *Write the letter that matches in the space provided.*

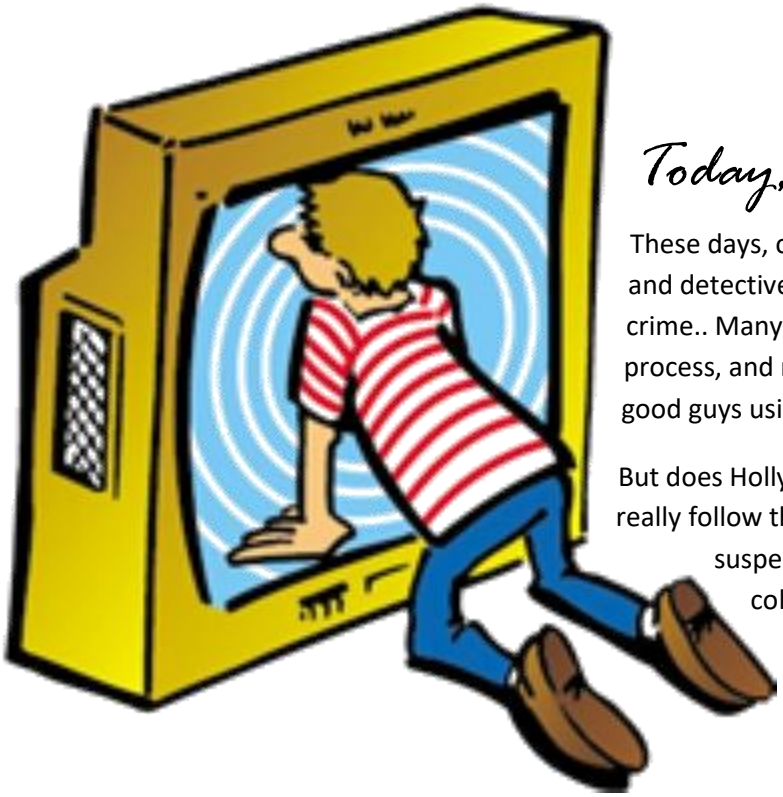
Antistius_____
Song Ci_____
Dr. Ambroise Paré _____
Eugène François Vidocq_____
James Marsh_____
Henry Goddard_____
Major L.W. Atcherley_____
Sir Edward Henry_____
Leone Lattes_____
Edmond Locard_____
Dr. Calvin Goddard_____
Landsteiner_____
Canadian crime lab investigators_____
The FBI and the National Bureau of Standards_____
William Bass III_____
The FBI_____
Neil McMurray and Geraint Williams_____

a) Performs the first recorded autopsy
b) Set up the first police crime laboratory in 1910
c) Developed a method for finding prints left by natural oils from the skin without fingerprint powder.
d) Developed the first computerized fingerprint database.
e) Used his own experience investigating murders to write the first forensic science textbook
f) Starts to build the first computerized nationwide system for matching DNA samples.
g) Uses a process to measure the concentration of elements in a material.
h) Developed his own system for fingerprinting
i) Carefully studied the effect of violent death upon human internal organs.
j) Pioneers the use of ballistics
k) Develops a method for determining the blood type of even a dried bloodstain
l) Used scientific methods to identify arsenic poisoning as the probable cause of death.
m) Establishes "The Body Farm,"
n) uses a comparison microscope to compare shell casings with samples fired by the police department's Thompson machine guns
o) Became the first person to use physical analysis to connect a bullet to the murder weapon.
p) Won the Nobel Prize for classifying human blood

FILE NO. 45780B

Who?	Who?	Who?
What?	What?	What?
Where?	Where?	Where?
When?	When?	When?

Who?	Who?	Who?
What?	What?	What?
Where?	Where?	Where?
When?	When?	When?



Today, in our World

These days, on TV shows viewers get to watch as investigators and detectives find and collect evidence at the scene of a crime.. Many of us believe we have a pretty good grip on the process, and rumor has it criminals are getting a jump on the good guys using tips they pick up from these shows.

But does Hollywood get it right? Do crime scene investigators really follow their DNA samples into the lab? Do they interview suspects and catch the bad guys, or is their job all about collecting physical evidence? Let's learn a bit from the Effective Detective.

So, what is Crime Scene Investigation?

The Effective Detective always says that crime scene investigation is the meeting point of science, logic and law. "Processing a crime scene" is a long, tedious process that involves purposeful documentation of the conditions at the scene and the collection of any physical evidence that could possibly shed light on what happened and point to who did it.

At any given crime scene **[what might an investigator do?]** a detective might collect dried blood from a windowpane -- without letting his arm brush the glass in case there are any fingerprints there, lift hair off a jacket using tweezers so he doesn't disturb the fabric enough to shake off any of the white powder in the folds of the sleeve, and use a sledge hammer to break through a wall that seems to be where a terrible smell is coming from.

In any investigation the investigators will formulate as many hypotheses (ideas and theories about what happened) as possible regarding the circumstances of the crime. **How might this work? What would detectives look at to get their theories? How would they narrow their ideas down?** The results of the evidence analysis will then be used to disqualify each hypothesis until one remains. **How might that work? What might disqualify a theory? If the theory about a broken window at your neighbor's house is that a burglar broke in, but then you find nothing missing…what might that mean?** If the evidence does not support the events of the final hypothesis the investigator then needs to develop a new hypothesis based on the evidence. **What if the investigator found a baseball under the couch at your neighbor's house? And your neighbor is an 80 year old lady, what new theory might you come up with?**

Detectives Hypothesis

Give students two quick scenarios and have them come up with a hypothesis about what happened? Explain they have a little detective work to do to figure out what happened.

You look all over your house to try and find your shoes. You are sure that you put them in a specific place but they are gone. You ask your mom and she says she didn't do anything to them? What do you think happened? Write down your hypothesis and what you would need to do to figure out if it was correct?

A neighbor gives you a candy bar that you bring in your backpack to school. You put it in your desk but when you return later in the afternoon to your desk it is gone? What do you think happened? Write down your hypothesis and what you would need to do to figure out if it was correct?

For your birthday you get a new puppy. At night afterschool you feed her and close her gate. In the morning you go out to see how she is. She is gone! The gate is still closed? What do you think happened? Write down your hypothesis and what you would need to do to figure out if it was correct?

What's needed in an investigation?

There are four main elements to an investigation. First, the crime scene is thoroughly documented. Photographs, videos, sketches and notes describing the scene are made. Second, the physical evidence is collected and unknown substances are sent to the laboratory for identification and analysis. Third, the results of the laboratory analysis of the physical evidence are compared to witness statements. Finally, both witness statements and laboratory results are used to disprove the investigator's hypotheses until one remains.

Who's at the Scene?

Have students brainstorm who might have to be at a crime scene. What have they seen on TV or read about that might help them think of people who would be there. Write down their ideas on the board. One way to do this is with a semantic map, draw a circle around the vocabulary word you are using, ex. crime scene, and give students 30-60 seconds to write all the different words that they associate with that one word.

Police officers are typically the first to arrive at a crime scene. They arrest the perpetrator if he's still there and call for an ambulance if necessary. They are responsible for securing the scene so no evidence is destroyed.

The **CSI unit** documents the crime scene in detail and collects any physical evidence.

The **district attorney** (lawyer) is often present to help determine if the investigators require any search warrants to proceed and obtain those warrants from a judge.

The **medical examiner** may or may not be present to determine a preliminary cause of death (how and why the person died) if a body is found at the crime scene.

Specialists (entomologists (scientists who study bugs), forensic scientists (people who apply science to the law), forensic psychologists (people who apply the science of psychology to legal matters, like in court cases) may be called in if the evidence requires expert analysis.

Detectives interview witnesses and consult with the CSI unit. They investigate the crime by following leads provided by witnesses and physical evidence.

All the while, the physical evidence itself is only part of the equation. **Why? What is the goal of collecting evidence?** The ultimate goal is the conviction of the perpetrator (whoever committed the crime) of the crime. So while the CSI scrapes off the dried blood without smearing any prints, lifts several hairs without disturbing any trace evidence and smashes through a wall in the living room, he's

thinking all of the necessary steps to keep the evidence in its current form and not ruin it, what the lab can do with this evidence in order to reconstruct the crime or identify the criminal, and the legal issues involved in making sure this evidence can be used in court.

The investigation of a crime scene begins when the CSI unit receives a call from the police officers or detectives on the scene. The overall system works something like this:

- The CSI arrives on the scene and makes sure it is secure. **Why would you want to secure a crime scene?** She does an **initial walk-through** to get an overall feel for the crime scene, finds out if anyone moved anything before she arrived, and generates initial theories based on visual examination. **Why would an investigator want to start making theories so early?** She makes note of potential evidence. At this point, she touches nothing. **Why not?**
- The CSI thoroughly **documents** the scene by taking photographs and drawing sketches during a second walk-through. Sometimes, the documentation stage includes a video walk-through, as well. She documents the scene as a whole and documents anything she has identified as evidence. She still touches nothing.
- Now it's time to touch stuff -- very, very carefully. The CSI systematically makes her way through the scene **collecting all potential evidence**, tagging it, logging it and packaging it so it remains intact on its way to the lab. Depending on the task breakdown of the CSI unit she works for and her areas of expertise, she may or may not analyze the evidence in the lab.
- The **crime lab** processes all of the evidence the CSI collected at the crime scene. When the lab results are in, they go to the lead detective on the case.

Every CSI unit handles the division between field work and lab work differently. What goes on at the crime scene is called crime scene investigation (or crime scene analysis), and what goes on in the laboratory is called **forensic science**. Not all CSIs are forensic scientists. Some CSIs only work in the field -- they collect the evidence and then pass it to the forensics lab. In this case, the CSI must still possess a good understanding of forensic science in order to recognize the specific value of various types of evidence in the field. But in many cases, these jobs overlap. Crime scene investigation is a massive undertaking and every detective is needed!

A Most Effective Detective

Tell students that during the next few days they are going to become Probationary Gumshoes, working under the guidance of the Effective Detective (you!), who will give them some evidence from a variety of old case files to practice their skills and help them become more effective detectives. Ask students how they would begin to solve a crime. How might they analyze the evidence discovered at the scene of the crime? Write students' ideas on a piece of

newsprint or a whiteboard.

What is Evidence?

Evidence is any statement or material object from which reasonable conclusions can be drawn. Sound like it could be a lot of things? Well, it can be, evidence is a broad category embracing anything that can be observed using the five senses, including documents, exhibits, facts agreed to by both sides, and the testimony of witnesses. Evidence in a criminal trial concerns the intent, motive, means, and opportunity to commit a crime.

In general, evidence is divided into two categories: circumstantial and physical. **What do students think circumstantial and physical evidence might be?**

• **Circumstantial evidence** consists of information gleaned from witnesses and documents that point to an individual as the perpetrator of a crime. It only allows for inferences and doesn't provide 100% proof.

• **Physical evidence** consists of actual objects, bodies, weapons, body-fluid stains, fingerprints, hairs, fibers, and so on, that are associated with the crime and may be linked to the perpetrator.

It is the work of forensic scientists and effective detectives to examine the physical evidence and, using the methods of science, to reconstruct the events that constituted the crime. The prosecutor must then combine this data with statements of witnesses and evidence from documents, such as emails, letters, text messages, telephone records, and credit card receipts, to develop an overall theory of the case, which can be presented in court.

All this evidence is used to prove three things, that someone has:

• **Motive:** A motive is a reason for committing the crime. Possible motives are passion, jealousy, greed, and revenge. Motive is usually determined through interviews and research.

• **Opportunity:** A suspect who can be placed at the scene of the crime, or was able to get to the scene of the crime within a certain time frame, can be said to have had opportunity.

• **Means:** A suspect considered by investigators to have been able to commit the crime can be said to have had means.

Splat!

Bloodstain patterns left at crime scenes may be examined for clues as to what may have occurred during violent crimes. **Ask students what they think blood could possibly tell investigators. What about the size and shape of blood drops, or simply the amount of blood?** Criminologists study the positions of both the victim's body and the assailant's body, and the pattern of blood spatter, found at a crime scene to determine how the incident occurred.

Forensic scientists examine size, shape, and distribution of the blood spatter. The goal of the following project is for students to create blood with a suitable viscosity to be used consistently throughout the project.

Setting the Scene

"Collect" blood spots/spatter (using appropriate blood recipe) from the Effective Detective's crime scene case files. Blood spatter should be consistent with the location of the injury, and the angle of spatter must be authentic, taking into consideration the height of the assailant. Blood may belong to a victim and/or suspect(s). The material on which the blood spatter is tested may be varied (for example, paper, cloth, wood, plastic, glass) simply use whatever is convenient.

In order to re-create crime scenes with scientific accuracy, a forensic scientist/effective detective needs to use materials that are identical to those used in a crime. As part of their training Probationary Gumshoes must develop and determine which material is best at replicating the effects and appearances of blood.

Once students successfully create their faux blood, they will release drops of artificial blood at different heights onto sheets of paper to reproduce drops of blood from evidence collected a crime scene by the Effective Detective and test velocity and angles and take measurements using the following activities. They will then examine the spatter from the crime scene and compare, trying to recreate it.

Materials

- simulated blood (see preparation/experiment instructions below)
- test tube
- dropper
- paper
- yard stick
- rulers
- ring stand
- Optional: blood that is preserved in chemicals from a science supply retailer; however, sterilized animal blood from a butcher's shop is another possible option.

What's the Best Recipe? Inquiry, Hypothesis, Variations, and Variables fake blood.

Recipes, directions, and experiment video found at:
http://www.stevespanglerscience.com/experiment/fake-blood-recipes. Accessed 9/27/11. All Rights Reserved.

If Halloween is coming up you could go to the store and buy a bottle of fake blood for your crime scene, but where's the scientific fun in that? And those bottles of fake blood never taste very good, do they? Students have a blast trying their own hand at following directions, forming hypotheses, measuring, mixing, and testing out recipes and variables to determine what recipe makes the best, most realistic,

and most delicious, edible fake blood (everyone likes chocolate, right?) for those crime scenes in the classroom and on the television. The following recipes are good starting places for students to start "tweaking" from.

Have students discuss and answer questions such as the following as they follow the process of scientific discovery and guided inquiry:

- What are the main characteristics of blood? Ex. thickness, color, etc. Is blood really bright crayon red? What color is it when it dries?
- What ingredients do you think will help you mimic/get those characteristics to make the most realistic fake blood?
- What ingredient should we try to help thicken it? [Corn syrup]
- What ingredient do you think might help make it less transparent? [corn starch]
- What ingredient will help darken the blood and add depth to the color? [chocolate syrup and powdered cocoa]
- What ingredient can help change the color slightly more brown? [green food coloring]

Note for Instructors: To get a good introduction to the process watch Steve Spangler make the following recipes at: http://www.stevespanglerscience.com/experiment/fake-blood-recipes

Materials

- Corn syrup
- Water
- Red food coloring
- Green food coloring
- Cornstarch
- Chocolate syrup
- Tropical fruit punch (Hawaiian Fruit Punch® works well)
- Powdered cocoa
- White towel

Corn Syrup Fake Blood

This is one of the most common recipes you find, but students will see that it doesn't really look anything like blood. That's okay… go ahead and make the batch because they'll use the ingredients a little later.

- 1 cup corn syrup (commonly sold under the name Karo Syrup)

- 1 tablespoon water
- 2 tablespoons of red food coloring
- A few drops of green food coloring
- Cheap white dishrags or towels

Combine all of these ingredients in the blender, or a bowl, and blend away for a few seconds. You can adjust the amount of green food coloring to make the blood a little more brownish-red in color. However, students should notice that the blood is a little too transparent. We can't see that well through real blood.

Have students take the white towel test… drip a few drops of blood onto a white towel to see how realistic it looks. Hmm, not there yet.

The Cornstarch Secret

Cornstarch is a common thickening agent for gravies, pie filling, and other goodies. It's also a great ingredient for fake blood because it adds a little opacity to the liquid.

- Use the mixture of the corn syrup recipe above
- 2 tablespoons of cornstarch

Place all of the ingredients in the blender and mix until the cornstarch dissolves. If the solution is too thick, add a tablespoon of water and blend the ingredients. Keep doing this until the blood is the perfect consistency.

Have students conduct the white towel test… drip a few drops of blood onto a white towel to see how realistic it looks.

The Chocolate Syrup Secret

In the days before color television, chocolate syrup was the perfect solution to the problem of making fake blood. On a black and white screen, chocolate syrup looked just like real blood. Even though times have changed, chocolate syrup is still an important ingredient in making great edible fake blood.

- 1 cup corn syrup
- 2 tablespoons water
- 2 tablespoons of red food coloring
- 1 tablespoon of chocolate syrup
- 2 tablespoons of cornstarch

Mix all of the ingredients in the blender for a few seconds. Watch as the fake blood oozes down the inside wall of the blender to get a good idea of what it will really look like on the white towel. Each of the ingredients in this recipe adds its own special quality to the fake blood – thickness, color, and transparency.

Have students take the white towel test… drip a few drops of blood onto a white towel to see how realistic it looks.

Blender Blood: the Best Fake Blood…So Far

This recipe combines everything you've learned so far about making fake blood and adds a few ingredients that pack a great punch (pun intended... as you'll see below).

- Tropical fruit punch (Hawaiian Fruit Punch® works great)
- 1 cup corn syrup
- 2 tablespoons of red food coloring
- 1 tablespoon of chocolate syrup
- 2 tablespoons of cornstarch
- 1 tablespoon of powdered cocoa

Have students combine all of the ingredients in the blender and mix for 10 seconds. Since different brands of fruit punch vary in color, they'll need to use their vast experience in making fake blood to tweak the recipe to arrive at their perfect batch of fake blood.

Some fake blood connoisseurs recommend a cup of coffee in place of the fruit punch. You may need to reduce (or eliminate) the amount of chocolate syrup and powdered cocoa used in the recipe. Remember, it's all about experimentation!

Have students conduct the white towel test … drip a few drops of blood onto a white towel to see how realistic it looks.

How does it work?

Have a discussion with students to see how the variables worked as they adjusted their mixtures...

- Corn syrup is used to thicken the liquid.
- Cornstarch is used to make the liquid less transparent.
- Chocolate syrup and powdered cocoa darken the blood, turning it reddish-brown, and add depth to the color.
- It may be necessary to add a few drops of green food coloring to change the color ever so slightly to the brown side. Mixing green and red makes brown and a few drops can do the trick.

Note: Vary the amount of flour and water to change the viscosity (tomato-based vegetable juice or tomato soup concentrate could also be used).

Spatter Patterns

Teacher tip from the Effective Detective: Prepare a number of mystery spatters ahead of time. Label or code them so that you have a record of the heights from which you dropped the blood.
Students will correlate the diameter of the spatter to their baseline data and determine the approximate height from which the drop of blood fell and take into consideration the height and angles involved in creating the blood spatter and how quickly the blood droplets were traveling. The trial heights may be varied and decided upon by students.

Blood Spatter Analysis

Materials
• simulated blood
• test tube
• dropper
• paper
• yard sticks
• rulers
• ring stand
Have students record their observations, data, and analysis in their *Forensic Investigation Lab Book*.

Comparing the Distance from which a Drop of Blood Falls to Its Diameter

1. Have students place newspaper on the floor and a clean sheet of white paper on top of the newspaper.
2. Hold a dropper 10 cm above the paper and drop **one** drop of blood. Remind them to be careful that they do not get blood on themselves, or on the floor, the table, or their materials. For more accuracy, you may have them clamp the dropper to a ring stand.
3. Have students measure the diameter of the spatter in millimeters or other grade level appropriate measurement and record their data in a data table
4. Have students repeat Steps 1 to 3 two more times and calculate the average diameter for a blood spatter at 10 cm.
5. Repeat this process, increasing the height from which they drop the blood each time.
They may need to stand on a table or chair. The heights printed in the following table are suggestions only.
6. Have students graph their data in a chart like the chart below.

Blood Splatter Analysis: Comparing Distance to Diameter

Distance	Diameter(cm)			
	Trial 1	Trial 2	Trial 3	Average
10				
40				
80				
100				
150				
200				

Splatter & Spray

[It is best to do this activity outdoors or in a very well-protected area.]
Forensic science determines a variety of facts about crimes using blood spatter evidence. In this activity students are investigators who use patterns to determine how and where the blood got where it did and recreate evidence from the Effective Detective's case files.

Materials:

- Fake blood
- White paper
- Sponge
- Hammer
- Measuring Devices (ex. rulers, protractors, string)

Have students attach white craft or poster paper to the wall and floor of a corner of the room. Wet a sponge with fake blood using a teaspoon but **don't** soak it. Place the sponge on the floor and hit it with a hammer. Let the spatter dry and have students examine the drops. Forensic investigators measure the ellipses that form to determine the position of the object that made the spatter and the angle that the drops impact the surface. Have students measure the length and width of five spots using grade level appropriate measuring tools. Ex. Have older students use the trigonometric function arcsin (sin-1) to determine the angle of blood spatter. Have younger students use string and tape to trace the angle back to the original sponge and measure it using protractors.

Have students hit the sponge at different angles and measure. Examine the drops to determine how far they traveled and patterns you see.

Alternate blood recipe: Mix 44 grams of cornstarch to 3 ounces of water and add 6 ounces of corn syrup and red food coloring to make your blood.

Applying the Science

Give each group a mystery spatter card that was pre-created. Have students measure the diameter and determine the distance from which the blood fell by comparing the diameter to the results they reached. Have students refer to their own data to make this determination.

Analyze the blood spatter evidence obtained at the crime scene. Determine the distance

(to the point of origin from which the blood fell) by comparing the diameter to the results obtained in Part 1.

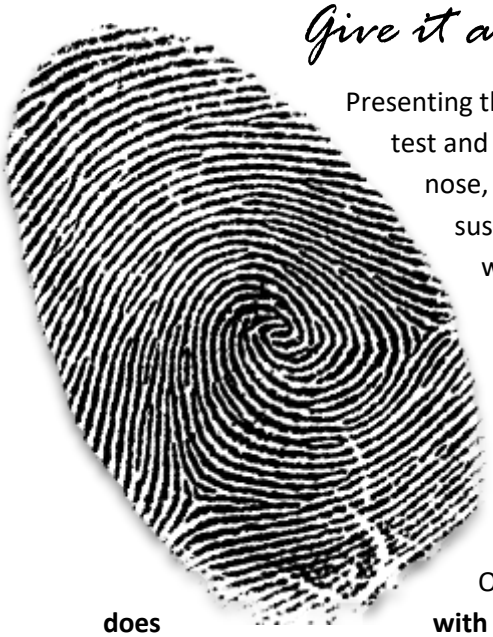
Discuss their results and have students describe the relationship between the distance of the fall and the diameter of a blood droplet. What other observations were they able to make about blood spatter?

Are there sources of error that could create problems for their technique? Like what? Have them list them and think about those points as though they were a legal expert attempting to question blood spatter evidence and whether it was any good.

Additional Practice: Math Detectives

Calling all Probationary Gumshoe math detectives! Mysteries are popping all over town, and our chief sleuth The Effective Detective needs your help to crack each case. Have students practice their mental math logical reasoning skills, whole number operations, fractions and ratios, combinations and probability, geometry, measurement and time by solving some of the Math Maven's mysteries at http://teacher.scholastic.com/maven/cafeteri/index.htm. Note: The mysteries are separated by topic and difficulty and there are printable versions of each.

Give it a Whorl: Fingerprinting



Presenting the Evidence: To gather evidence from "old case files" for students to test and see, have a volunteer rub his or her finger across the bridge of the nose, across the temples, or through the hair (to gather oils). Then have the suspect press firmly with finger(s) on a clean glass or clear plastic cup without smudging. A partial print from another person, or the same, will make the investigation more interesting. The print should be faintly visible.

Class Discussion: Imagine you see on TV that there has been a break in. When the detectives arrive on the scene, the house is in shambles. Clothes are strewn about the floor, lamps are overturned and there's no sign of the assailant. Then, one of the detectives picks up a glass. On its side is a smudged thumbprint. **Ask students what they think he does with it.** He takes it down to the lab, where it's analyzed and matched to a recorded set of prints. **Then what happens?** The detectives catch the thief.

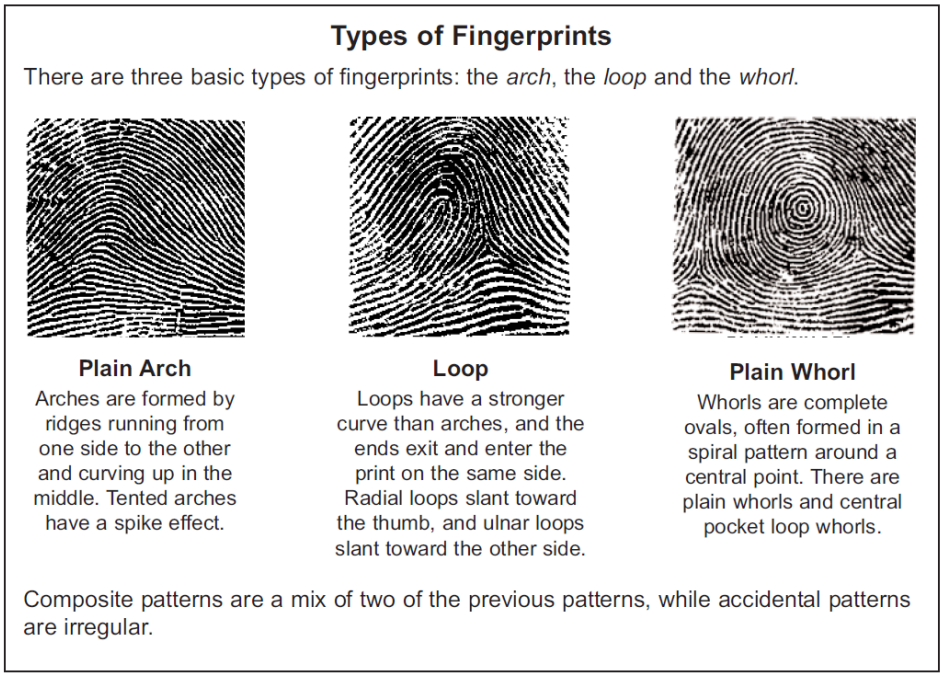
This scene has been replayed on TV over and over. Ever since scientists discovered that every person's fingerprints are unique, and police officers realized this one unique thing could help them catch criminals, fingerprints have been an important part of the law enforcement process. **Today, fingerprints are also used for what?** To prevent forged signatures, identify -accident victims, verify job applicants and provide personalized access to everything from ATMs and cars to computer networks and cell phones.

But fingerprinting has come a long way from the days when police officers lifted prints from a crime scene and checked them manually against their files. Modern fingerprinting techniques can not only check millions of criminal records simultaneously, but can also match faces, backgrounds and other identifiable characteristics to each perpetrator.

What are the basic characteristics of a fingerprint? Have students ever seen their fingerprint? Where? Almost every time you touch something, you leave a fingerprint. **Have students ever seen computer screens, touch screen phones, or windows with fingerprints on them?** Fingerprints are impressions that are created by ridges on the skin. When a person touches an object, the perspiration, oils, dirt, and cells on the skin stick to the surface of the object, leaving an imprint of your fingertips. Prints that you can see with the unaided eye are called visible prints. Invisible prints are called latent prints, and they are the most common. A third type of print is a plastic print. This print is an impression on objects such as soap or clay. A forensic scientist is interested in fingerprints as a means of identification to help solve crimes. **How could fingerprints help solve crimes?** *Dactyloscopy* is a technique used to compare fingerprints for identification.

How long have people been using prints as a form of identification?

[During the following discussion, you may want to have students identify and mark on a map the locations of fingerprint analysis development as you discuss] There are records of fingerprints being taken many centuries ago, although they weren't nearly as sophisticated as they are today. The ancient Babylonians pressed the tips of their fingertips into clay to record business transactions. The Chinese used ink-on-paper finger impressions for business and to help identify their children. In 1000, a Roman attorney showed that a palm print was used to frame someone for murder.



A fingerprint is an individual characteristic. No two identical fingerprints have been taken from different individuals, not even from identical twins. **What other things do students know of that there are no two exactly alike? Ex. snowflakes, eye patterns, what else?** A fingerprint will remain unchanged during an individual's lifetime. **What might happen if your fingers got burned or cut?** Injuries such as burns or scrapes will not change the ridge structure; when new skin grows in, the same pattern will come back. Fingerprints have general characteristic ridge patterns that permit them to be systematically classified. The individuality of any fingerprint is based upon its ridge structure and specific characteristics. The specific characteristics of individual fingerprints used for identification are the number of ridges and their approximate location. The average fingerprint has 150 individual ridge characteristics. A match is assumed if between 10 and 16 specific points of reference correspond exactly. **Why do students think it takes so few points to be considered a match?**

However, fingerprints weren't commonly used as a method for identifying criminals until the 19th century. In 1858, an Englishman named Sir William Herschel was working as the Chief Magistrate of the Hooghly district in Jungipoor, India. In order to reduce fraud, he had the residents record their fingerprints when signing business documents. **Why and how would this reduce fraud? What is fraud?**

A few years later, Scottish doctor Henry Faulds was working in Japan when he discovered fingerprints left by artists on ancient pieces of clay. This finding inspired him to begin investigating fingerprints. **What drives many humans, including scientists, to make discoveries? Curiosity!** In 1880, Faulds wrote to his cousin, the famed naturalist Charles Darwin, and asked for help with developing a fingerprint classification system. Darwin declined, but forwarded the letter to his cousin, Sir Francis Galton.

Galton was a eugenicist (a scientist who wanted to improve the human race by controlling who had children, etc) who collected measurements on people around the world to determine how traits were inherited from one generation to the next. **Why do students think people and scientists care how and why certain traits are passed?** He began collecting fingerprints and eventually gathered some 8,000 different samples to analyze. In 1892, he published a book he creatively called *Fingerprints*, in which he outlined a fingerprint classification system -- the first in existence. The system was based on patterns of arches, loops and whorls.

Meanwhile, a French law enforcement official named Alphonse Bertillon was developing his own system for identifying criminals. Bertillonage (or anthropometry) was a method of measuring heads, feet and other distinguishing body parts. These "spoken portraits" enabled police in different locations to apprehend suspects based on specific physical characteristics. The British Indian police adopted this system in the 1890s.

Also, around the same time, Juan Vucetich, a police officer in Buenos Aires, Argentina, was developing his own variation of a fingerprinting system. In 1892, Vucetich was called in to assist with the investigation of two boys murdered in Necochea, a village near Buenos Aires. Suspicion had fallen initially on a man named Velasquez, a love interest of the boys' mother, Francisca Rojas. But when Vucetich compared fingerprints found at the murder scene to those of both Velasquez and Rojas, they matched Rojas' exactly. She confessed to the crime. This was the first time we know of that fingerprints had been used in a criminal investigation. Vucetich called his system comparative dactyloscopy. It's still used today in many Spanish-speaking countries.

At the same time and with no knowledge of Vucetich's work in Argentina Sir Edward Henry, commissioner of the Metropolitan Police of London, became interested in using fingerprints to nab criminals. In 1896, he added to Galton's technique, creating his own classification system based on the direction, flow, pattern and other characteristics of the friction ridges in fingerprints. Examiners would

turn these characteristics into equations and classifications that could distinguish one person's print from another's. The Henry Classification System replaced the Bertillonage system as the primary method of fingerprint classification throughout most of the world. **Why do students think so many different men in completely separate areas of the world were trying to answer and solve the same kind of human problem?**

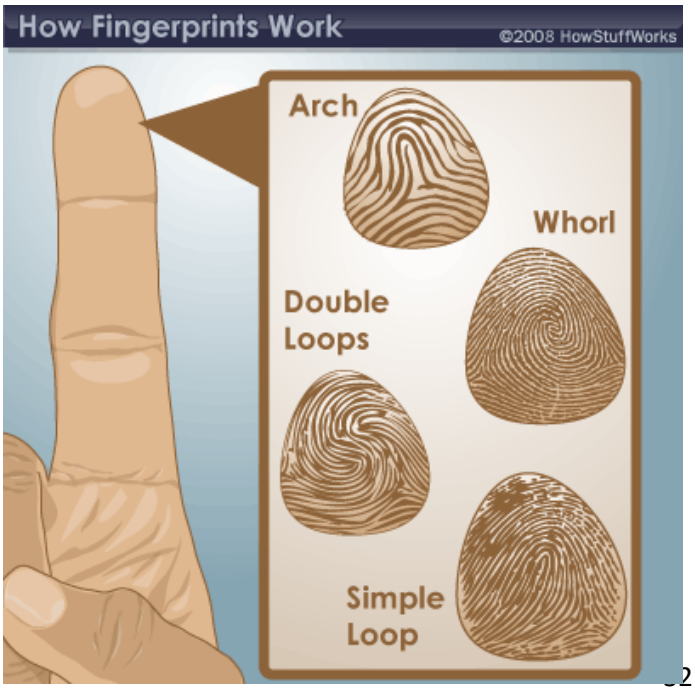
In 1901, Scotland Yard established its first Fingerprint Bureau. The following year, fingerprints were presented as evidence for the first time in English courts. In 1903, the New York state prisons adopted the use of fingerprints, followed later by the FBI.

What are Fingerprints?

Fingerprints are the tiny ridges, whorls and valley patterns on the tip of each finger. They form from pressure on a baby's tiny, developing fingers in the womb. No two people have been found to have the same fingerprints -- they are totally unique. There's a one in 64 billion chance that your fingerprint will match up exactly with someone else's. Fingerprints are even more unique than DNA, the genetic material in each of our cells. Although identical twins can share the same DNA -- or at least most of it -- they can't have the same fingerprints.

Fingerprinting is one form of **biometrics**, a science that uses people's physical characteristics to identify them. **What other characteristics can people be identified by?** Fingerprints are ideal for this purpose because they're inexpensive to collect and analyze, and they never change, even as people age. **What characteristics change as we age? Hair color, appearance, height?**

Although hands and feet have many ridged areas that could be used for identification, fingerprints became a popular form of biometrics because they are easy to classify and sort. They're also accessible, you can't always get someone to take their shoes off!



Fingerprints are made of an arrangement of ridges, called **friction ridges**. Each ridge contains pores, which are attached to sweat glands under the skin. You leave fingerprints on glasses, tables and just about anything else you touch because of this sweat.

All of the ridges of fingerprints form patterns called loops, whorls or arches:

- **Loops** begin on one side of the finger, curve around or upward, and exit the other side. There are two types of loops: **Radial loops** slope

toward the thumb, while **ulnar loops** slope toward the little finger.

- **Whorls** form a circular or spiral pattern.
- **Arches** slope upward and then down, like very narrow mountains.

Scientists look at the arrangement, shape, size and number of lines in these fingerprint patterns to distinguish one from another. They also analyze very tiny characteristics called **minutiae**, which can't be seen with the naked eye.

If fingerprints are so unique and subtle, how are they recorded accurately?

Dactyloscopy: the art of fingerprinting

The technique of fingerprinting is known as dactyloscopy. Until the advent of digital scanning technologies, fingerprinting was done using ink and a card.

To create an ink fingerprint, the person's finger is first cleaned with alcohol to remove any sweat and dried thoroughly. The person rolls his or her fingertips in ink to cover the entire fingerprint area. Then, each finger is rolled onto prepared cards from one side of the fingernail to the other. These are called rolled fingerprints. Finally, all fingers of each hand are placed down on the bottom of the card at a 45-degree angle to produce a set of plain (or flat) impressions. These are used to verify the accuracy of the rolled impressions.

Today, digital scanners capture an image of the fingerprint. To create a digital fingerprint, a person places his or her finger on an optical or silicon reader surface and holds it there for a few seconds. The reader converts the information from the scan into digital data patterns. The computer then maps points on the fingerprints and uses those points to search for similar patterns in the database.

Law enforcement agents can analyze fingerprints they find at the scene of a crime. Remember, there are several different types of prints:

1. Visible prints are made on a type of surface that creates an impression, like blood, dirt or clay.
2. Latent prints are made when sweat, oil and other substances on the skin reproduce the ridge structure of the fingerprints on a glass or any other surface the perpetrator has touched. These prints can't be seen with the naked eye, but they can be made visible using dark powder, lasers or other light sources. Police officers can "lift" these prints with tape or take special photographs of them.

Quick Review Q's: When did this basic form of identification become a law enforcement staple? How did Babylonians and the ancient Chinese use fingerprints?

A Classy System

The Henry system finally enabled law enforcement officials to classify and identify individual fingerprints. Unfortunately, the system was very cumbersome. When fingerprints came in, detectives would have to compare them manually with the fingerprints on file for a specific criminal (that's if the person even had a record). **What might be the problem with that?** The process would take hours or even days and didn't always produce a match. By the 1970s, computers were in existence (**how could computers help solve the problem?**), and the FBI knew it had to automate the process of classifying, searching for and matching fingerprints. The Japanese National Police Agency paved the way for this automation, establishing the first electronic fingerprint matching system in the 1980s. Their Automated Fingerprint Identification Systems (AFIS), eventually enabled law enforcement officials around the world to cross-check a print with millions of fingerprint records almost instantaneously. **How does that help police?**

AFIS collects digital fingerprints with sensors. Computer software then looks for patterns and minutiae points (even today, it's still based on Sir Edward Henry's system) to find the best match in its database.

The first AFIS system in the U.S. was speedier than previous manual systems. However, there was no coordination between different agencies. **What problems could that cause?** Because many local, state and federal law enforcement departments weren't connected to the same AFIS system, they couldn't share information. That meant that if a man was arrested in Phoenix, Ariz. and his prints were on file at a police station in Duluth, Minn., there might have been no way for the Arizona police officers to find the fingerprint record. **And then what might happen?**

That changed in 1999, with the introduction of Integrated AFIS (IAFIS). This system is maintained by the FBI's Criminal Justice Information Services Division. It can categorize, search and retrieve fingerprints from virtually anywhere in the country in as little as 30 minutes. It also includes mug shots and criminal histories on some 47 million people. IAFIS allows local, state and federal law enforcement agencies to have access to the same huge database of information. The IAFIS system operates 24 hours a day, 365 days a year.

But IAFIS isn't just used for criminal checks. It also collects fingerprints for employment, licenses and social services programs (such as homeless shelters). **Why might fingerprints need to be collected for those purposes?** When all of these uses are taken together, about one out of every six people in this country has a fingerprint record on IAFIS.

Despite the modern technologies, fingerprinting is still an old detective's trick, but a very effective one!

If you want to use fingerprints to solve crimes, you must have a way to describe and sort and find prints that are similar to the one you find at a crime scene. The FBI has over 200 million prints on file; they can't personally look through every single one to find a match!

Fingering it Out!

Ask the guiding question: Can we invent a new, better, or any way to classify fingerprints for the Effective Detective? Students are going to fingerprint themselves, compare and classify prints, create a database, and see how we might sort them into categories, just as fingerprint specialists do, in their training to become a more Effective Detective.

Materials

- Magnifying Glasses
- Balloons
- Handouts
- Ink Pad or Permanent Marker
- Markers
- Large Sheets of Paper (used for graph)
- Soap for clean up!

Ballooning Prints

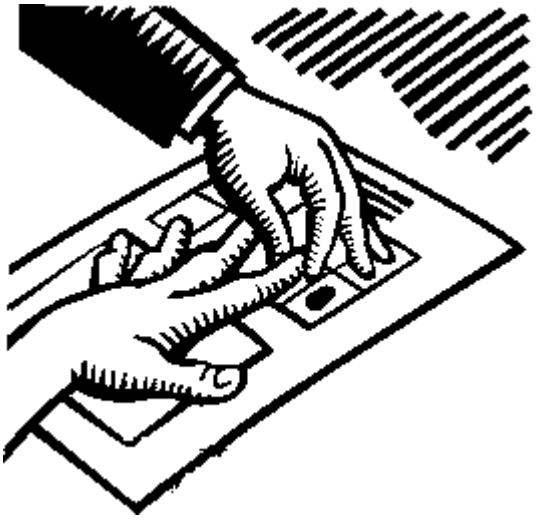
For this fingerprint activity, you will need a balloon and a marker for each student. Instruct the children to take a marker and color their fingertips, one at a time. (**They will probably color only one finger for this activity.)** Note: It works best with a Sharpie, but other non-permanent markers may be used.

1. Have students carefully place a finger down on the balloon, being careful not to smear the fingerprint.
2. Repeat with the other fingers.
3. Now tell the students to inflate the balloons until the prints become big and clear. They may need to fill the balloon more or take some air out in order to get the prints enlarged but clearly visible.
4. Discuss how sometimes police officers must work with a partial set of fingerprints or smeared prints at a crime scene. Have students identify which of their prints are clearest and discuss ways police officers may use fingerprints to solve crimes.

Printmaking

1. Divide participants into groups of 2-6
2. The use of ink from a pad (though it can be messy and difficult to clean off hands) is the simplest method for making fingerprints. The finger is covered with ink and then firmly rolled on the space on their chart, a piece of paper, or a blank index card. If using graphite pads, have everyone rub a pencil over the central part of an index card until it is covered with graphite.

3. Give everyone another card for recording his/her prints and have them write their names on the lined side and turn it over.
4. Each participant will be making prints of the fingers of the same hand. Begin by asking who is right- or left-handed and tell them to use only that hand.
5. Note to participants that they want to make prints *not* of their finger*tips* but of the pads of their fingers, near the joint crease, because that is where the most interesting patterns are.

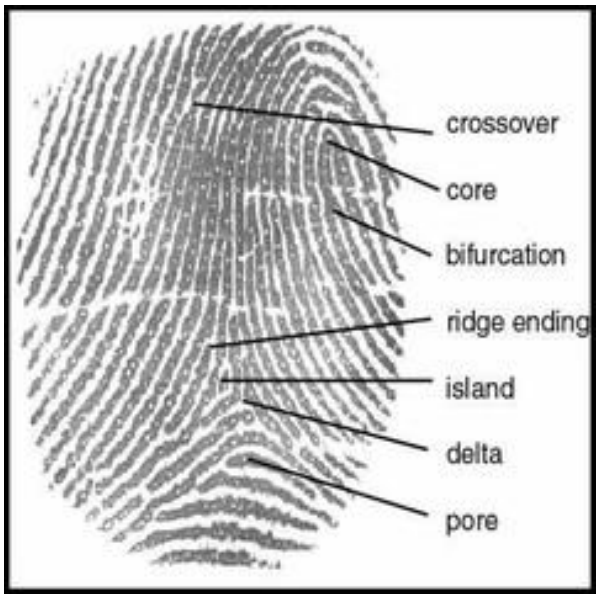


6. Many times, printmaking is best done with a partner: Have students roll the pad of their finger very gently on the "ink" pad and then let your partner roll it slowly and *very gently* on the label. This is most easily done right at the edge of their table or desk. They do not need to press hard at all; if you do, you will get a black smudge with very little readable pattern. They can do the whole procedure themselves, but it usually comes out clearer with a partner's help. *The Federal Bureau of Investigation suggests either rolling the fingers from nail-to-nail or using the "flat" procedure whereby all right and left forefingers are inked first, followed by the two thumbprints.*
7. If using graphite pads, press and roll their finger firmly on the penciled area, then stick a short piece of tape to the finger pad area, pressing down thoroughly, remove the tape and press it onto their print record card.
8. Immediately label your print "L" or "R" for left or right hand and "I" or "M" for index or middle finger.
    - T for thumb
    - I for index finger
    - M for middle finger
    - R for ring finger
    - L for little finger
9. Repeat procedure for the second finger. Do it over until you get two good prints.
10. After all prints are made and labeled, have partners in each group compare their prints using magnifying glasses and looking for similarities and differences.
    - Are the two prints from the same hand more alike than prints from different people? How?
    - What kinds of patterns do they see? Help them give names to the patterns (circles, triangles, curvy lines)
    - After some time, give them the handout with examples of "official" names for patterns (loops, whorls, and arches).
    - What are the positions of those patterns on the finger (how close they are to the joint line)?
    - In which direction do the loops curve—toward the thumb or toward the pinkie finger? (Remember that taped prints are like looking at your finger palm-up and inked prints are mirror images. It may be easier to ask whether they curve toward the right or left of the card.)
    - Compare the size of those patterns (such as how many ridges make up a loop).

- Could they identify these prints as theirs? Have students hypothesize whether or not related people will have more similarities in their fingerprints than those who are not related. If possible in your student group, find a variety of siblings. Study the prints to categorize each as loop, whorl, arch or abstract. Separate prints to compare with those not related to determine the percentage of similar prints in the related and non-related groups of prints. Did their conclusions support their hypothesis?
- Try it: Tape with a fingerprint may also be placed on an overhead and the fingerprint projected for the class to analyze.

11. Besides the basic labels of arch, loop, or whorl, there are small details, called minutiae that we can use to compare fingerprints.
12. Note where ridges cross over or end. Sometimes a ridge will split, which is called a bifurcation. You may be able to compare the valleys between the ridges; a delta is a 3-way valley. Also, the little dots visible on your fingerprint are sweat pores!

13. Keep in mind when we compare fingerprints we won't always get an exact match. This is because we touch things with the tips or sides of our fingers so we may need to rotate the prints in order to compare them.



14. Discuss with students how, while scars, such as the white line on one of the sample prints in this lesson, are the easiest patterns to see, they cannot be used either for classification or identification. They are not unique in the way that ridge patterns are, and they also change over time—making them unreliable for these purposes.

15. Divide the participants up by patterns, either grouping them physically or grouping their cards by pattern.
16. Ask how you might look most efficiently for a particular pattern. For example: “In which of these groups would I look for a loop that leans to the left? Would it make sense to look through the whorls?”
17. Which is the most common pattern? Have students graph results, and/or figure fractional or percentage representation of each type. A suggestion about the set up of the graph would be to use different colored dot stickers and have the children fingerprint their index finger right onto the sticker. Then they can place it in the correct column and write their name right next to their fingerprint!

Ask students again, how can fingerprints be classified? How does classification make it easier to match one print against a database of many? [Simplify the classification of fingerprints by using the three major categories: loop, arch, and whorl. Using these categories, students should be able to identify their fingerprints.] Ex. Students may suggest that they could store results in a three-ring binder, creating pages for each student from whom a fingerprint is collected.
Have students develop a plan to search systematically for a specific person: for example, to look through the left-leaning loops with eight ridges that are close to the finger joint.

Note: Fingerprints are a very personal kind of information; at the end of the unit let participants take their prints home with them.

Weather Permitting?

Show the impact of environment elements on a fingerprint with this project. Have students test fingerprints on a glass surface for its resistance to "sun" (heat), "snow" (cold) or "rain" (water). Have students determine how to test the fingerprint with the classroom elements they have available, ex. they may want to conduct the heat test in an oven or microwave set at the temperature of choice or with hot water, a freezer or ice cubes inside the glass for the element of cold, and they might imitate rainfall by spritzing or splashing the glass with water. Have students examine the fingerprints afterward with a magnifying glass and record the results. Which element and print combination has the best quality after exposure?


Loop


Central pocket loop


Double loop


Plain arch


Tented arch


Plain whorl

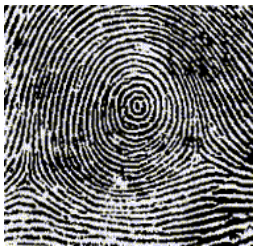

Loop


Central pocket loop


Double loop


Plain arch


Tented arch


Plain whorl

Dusting for Prints

Have students collect fingerprints from evidence collected by the Effective Detective at the crime scene and use their recently created fingerprint classification system to match an unknown fingerprint from their known samples. Note: Getting good results from dusting for fingerprints can be challenging, and may require plenty of practice.

Materials (depending on choice of activities and/or methods)

- cocoa (light surface) or talcum powder (dark surface)
- stamp pads (washable ink)
- glasses or plastic cups (or other surface) for fingerprints
- small soft brushes (soft camel hair or fibreglass)
- superglue (the larger tubes work better than the tiny tubes)
- zippered plastic evidence bag (large enough for the object with the fingerprints)
- magnifying glass
- construction paper
- white paper
- transparent tape
- index cards
- Sieve

Collecting Fingerprint Evidence from the Crime Scene (from hard surfaces)

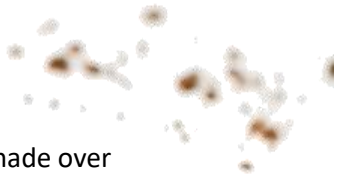
At the crime scene, fingerprints must be removed and transported to the crime lab. They may then be compared to the database of fingerprints on file. One way that detectives locate fingerprints is by dusting for them. Fingerprints are coated with powder, then lifted, sealed, and taken for identification at the lab.

To Practice:

Tell the students to run their fingers over their nose, forehead or scalp to collect oil on their fingertips. Then have the children press their fingers onto a clean, plastic cup. Next, have the students carefully dust the surface of the cup with cocoa powder. (We found this easiest to do by spooning cocoa powder into a sieve, then dusting the print but kids might feel a bit more official in the process if they use a clean paintbrush to dust the cup with cocoa powder.) Have the students carefully blow away the excess powder. Students should then take a section of packing tape and carefully apply it to the fingerprint area and then lift it up and reapply it to a piece of white paper. Let the class look closely at their prints with a magnifying glass. (Have the students compare the prints to those on the balloon.)

At the crime scene:
1. Have students sprinkle a bit of cocoa powder over the object (for instance, a glass) and brush the powdered area gently with a fine brush (camel hair or fiberglass) to remove the excess powder and expose the print. On dark surfaces, have students use talcum powder instead of cocoa to lift the print.
2. Place a piece of transparent tape over the print and lift the print from the glass. Place the tape on light colored construction paper.

Alternative Method: Have students place the object (for example, cup) in a labeled zippered plastic evidence bag and then add about three to ten drops of superglue to a cotton ball and put the cotton ball in the bag, making sure that the drops do NOT hit the actual fingerprint, seal the bag, and put it in a warm place. In about an hour, the fingerprints should be clearly visible in white. **As the fingerprints begin to reveal themselves inquire as the how the process could be improved by real scientists and what would be an example of ways to improve it.**



History: For nearly 80 years, dusting was the only widely used method for finding fingerprints on smooth surfaces. Various incremental improvements were made over the decades–including the introduction of better powders, fluorescent powder that glowed, and magnetic powders–but dusting for fingerprints in 1975 was essentially unchanged from print dusting in 1900. While fingerprint usage spread rapidly, fingerprint categorization and detection evolved slowly until a remarkable accident in 1977. Fuseo Matsumur was a hair and fiber expert at the Saga Prefecture Crime Laboratory of the National Police Agency of Japan. He used a microscope to examine trace evidence to solve crimes. The evidence would be mounted on glass slides with superglue. One day, while working on a taxi driver murder case, Matsumur noticed his fingerprint developing on the slide.

Intrigued, Matsumur took the slide to his colleague, Masato Soba, who experimented with his own fingerprints. Soba eventually developed a technique for developing fingerprints with superglue which is still used today.

A fingerprint leaves traces on smooth surfaces. These are not usually visible to the naked eye. However, superglue, or cyanoacrylate, is highly attracted to these substances. In superglue fuming, a small amount of Cyanoacrylate is heated, which produces cyanoacrylate gas. The gas circulates and eventually sticks to the substances left behind by the fingerprint, allowing the print to be photographed or "lifted." In 1979 the japanese police demonstrated the fingerprint fuming method

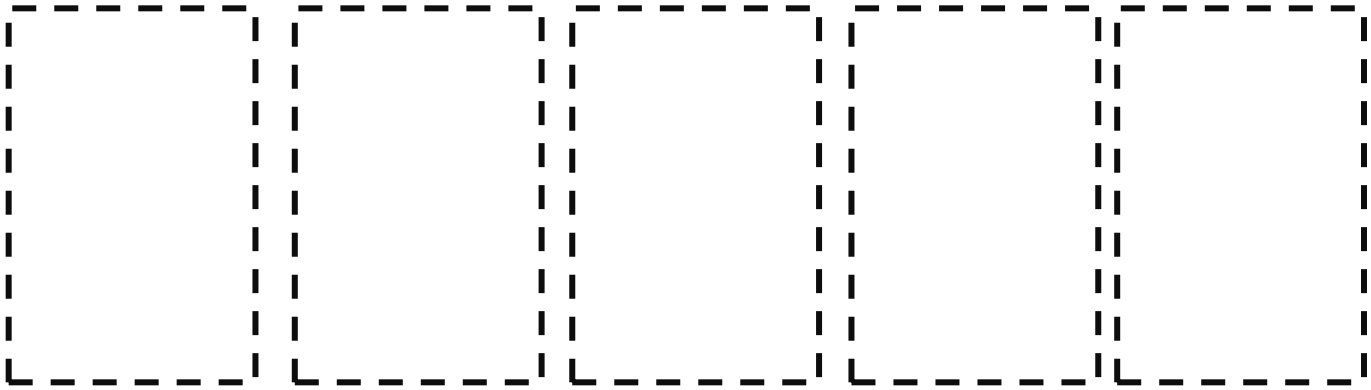
for Latent Print Examiners from the U.S. Army Crime Laboratory, who brought the procedure back to the United States in April, 1980. Superglue fuming is still used in most crime labs around the world. Although not as glamorous or complex as other methods, the persistence of superglue fuming proves its effectiveness.

Extension: Mystery Visitor

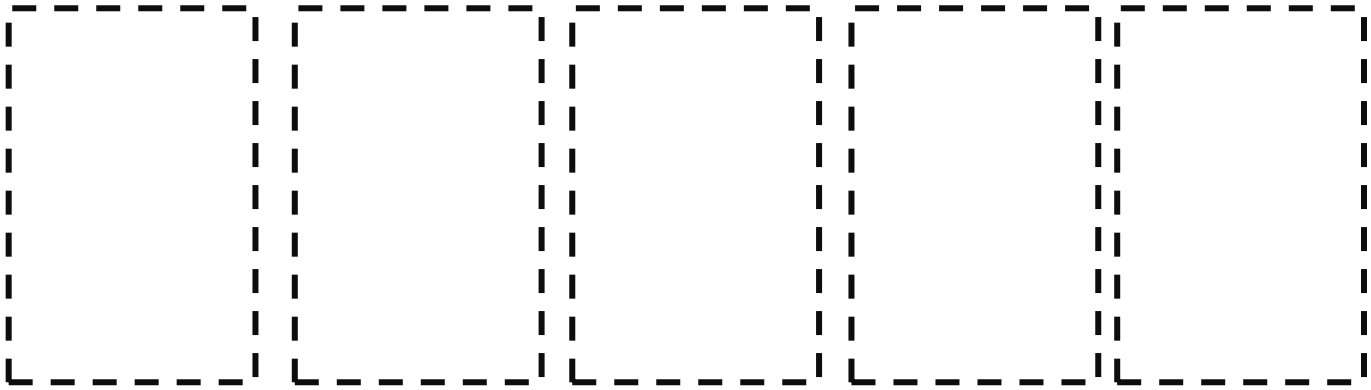
Divide the students into teams. Each team should secretly choose one member to be the mystery visitor. Then have each team put together evidence for the rest of the class to investigate. Students can use fingerprints, footprints, handwriting samples, hair samples, and fiber samples as evidence that can be collected and analyzed. By analyzing the physical evidence, other teams can determine who in the group was the mystery visitor.

FILE NO. 45780B

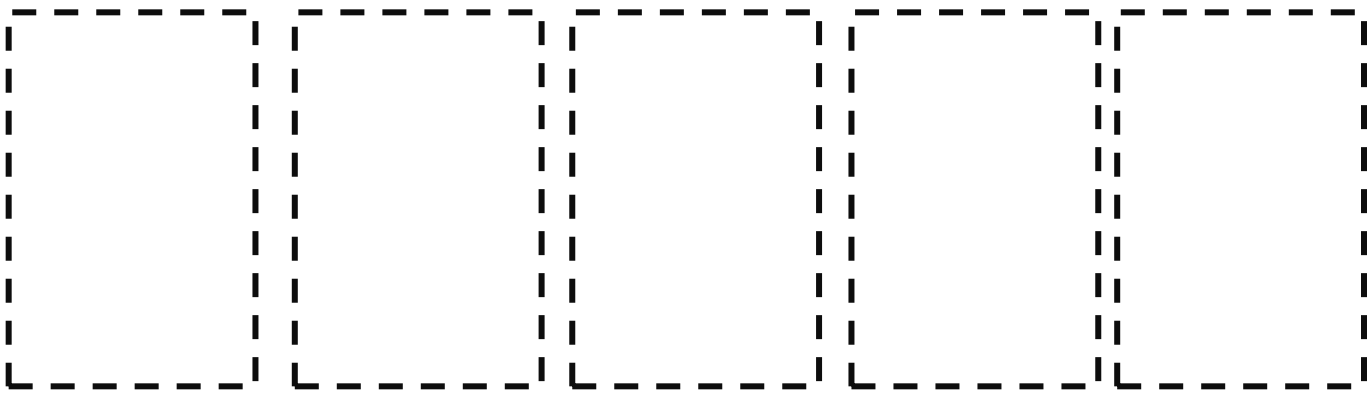
Fingerprint Record



Fingerprint Record



Fingerprint Record



Leaving an Impression

Impression evidence is very important in the field of forensic science. Impressions that are left behind at a crime scene can provide Effective Detectives with clues as to the object or individual who may have left the mark. In the following we are going to explore two types of impression evidence—footwear impressions and bite marks—and students will complete activities for each.

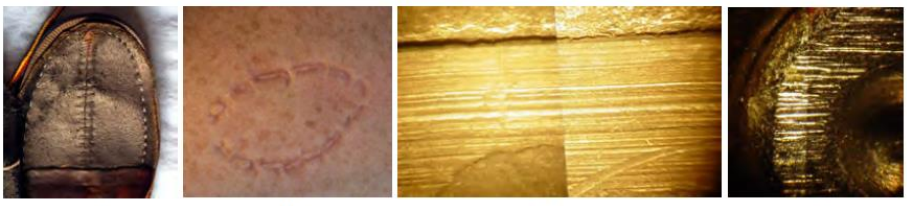
What is Impression Evidence?

When objects such as footwear, tires, tools, etc. are used with a little bit of pressure, they are capable of leaving behind what is called an impression. These impressions have the characteristics of the type of object that created them, including any imperfections that exist on the surface of the object. There are two types of impression evidence: compression and scraping/striated evidence.

Compression evidence consists of marks that are made when one object is pushed or forced into another that is soft enough to be marked. Shoeprints, tire tracks, bite marks; impressions from tools striking a surface, and marks on fired cartridge cases are all examples of compression evidence. Whereas compression evidence is created only through the application of pressure, scraping or striated evidence is created through a combination of pressure and sliding contact. This means that impressions can be left when one object slides across or against another object while a force holds the two objects together. **Have students think of examples of things that might slide against something else. Shoes, tires, etc.** A good example of this is with a firearm or gun. Many firearms have what is called rifling. This means that during the manufacturing process, a series of grooves are cut into the inside of the gun's barrel. When that gun is then fired, the bullet is squeezed through and then forced out of the barrel. As the bullet moves through the barrel, it scrapes against the rifling which leaves scratches, which detectives call striations. If the bullet is recovered, those striations can be matched back to the barrel that made them, rather like a fingerprint, thus indicating the firearm that was used. Another example of scraping or striated evidence would be a surface over which the blade of a screwdriver was dragged.

Types of Impression Evidence

Given that there are many different types of objects that can come into contact with other objects, there is a very broad spectrum of impressions that can be created. However, in terms of crime scene investigation, there are several specific types of impressions that are



(a) (b) (c) (d)

Figure 2.1 Impressions. (a) Foot inside a shoe, (b) Bitemark, (c) Toolmark, and (d) Breech marks and firing pin on bullet.

Source: Courtesy of Edward Robinson, George Washington University.

often found at a crime scene. **[Have students give their ideas and list them on the board]** These impressions include:

- Footwear
- Tires
- Tools
- Bite marks
- Fabric
- Ligature or binding

Each of these types of impressions is unique, and therefore has a specific way that it is documented, collected, and preserved.

Bite Marks

In forensic investigations, dental records are used to match teeth to victims and suspects. Identification by teeth is not new. Forensic Odontology (dentistry) has been used as far back as the Roman Empire to identify victims of crime and other mishaps. It goes back as far back as 66 A.D. at the time of Nero. As the story goes, Nero's mother, Agrippina, had her soldiers kill Lollia Paulina, with instructions to bring back her head as proof that she was dead. Agrippina, unable to positively identify the head, examined the front teeth and on finding the discolored front tooth confirmed the identity of the victim.

Teeth are highly resistant to destruction and decomposition, so dental identification can be made under extreme circumstances. It was used on Adolf Hitler and Eva Braun at the end of World War II, to identify victims of the New York City World Trade Center bombing, and numerous airplane crashes and natural disasters. The U.S. has a fairly well-developed system of dental records (the Universal System) kept by those whom we see whenever we are concerned about our teeth: our dentists and orthodontists. This system is often used for the identity of remains or "Jane Doe" victims. X-rays are extremely useful in the determination of tooth decay, or the need for root canals. They are also extremely helpful in determining the identity of the person by the nature of the unique pattern of dental work that has been performed on that individual. This is especially useful in the case of victims of fire. Fire can so severely damage a body as to make identification of facial features impossible. In such cases, the mouth remains surprisingly

Digging Up Crime in the Rubble

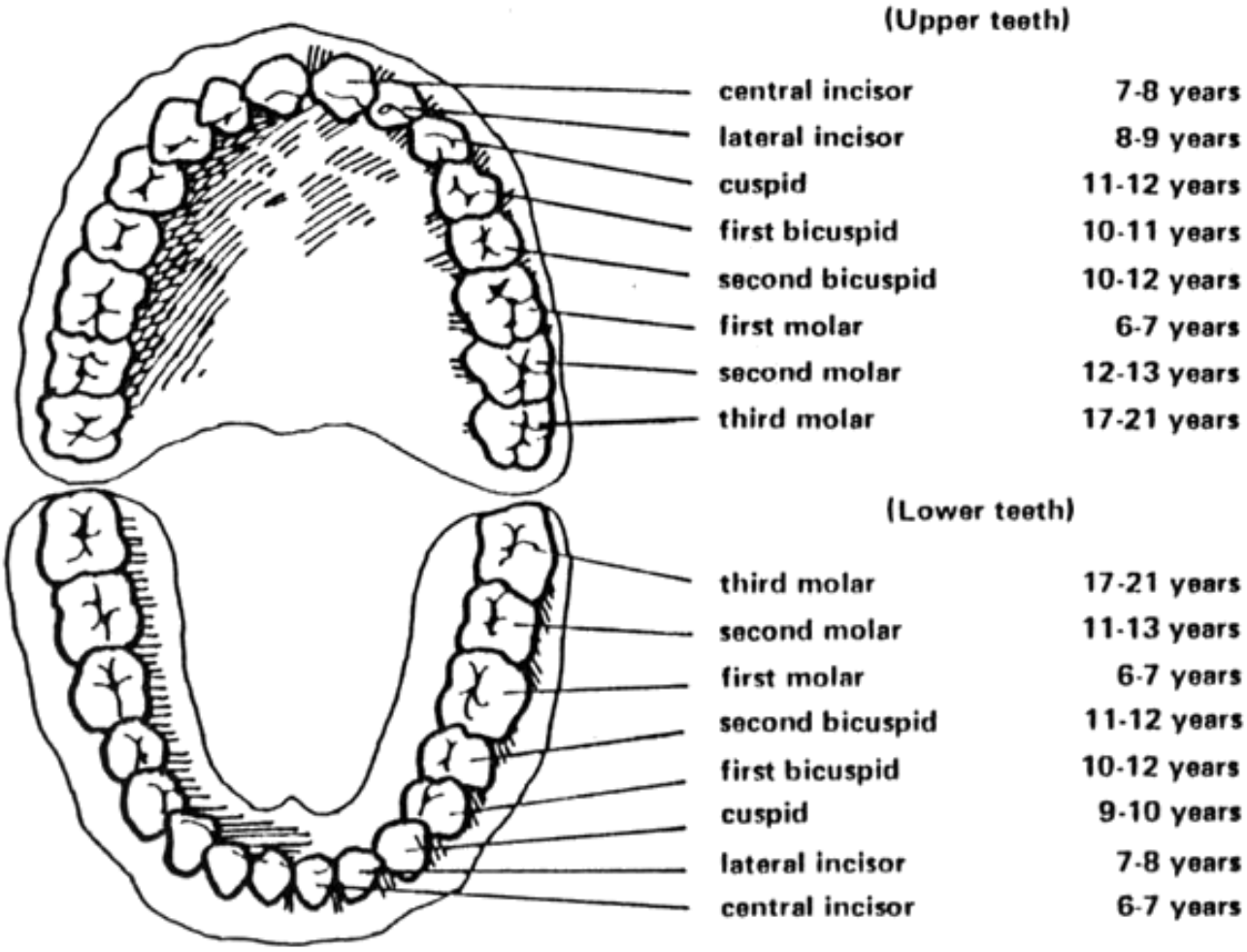
After September 11th, 2001, the nation watched in horror as many brave men and women searched in the rubble of the twin towers, searching for survivors. Ultimately, as time passed, the search shifted from a search for the living to a search for the dead. In some cases, the only way to identify a body was through the teeth. One part of matching is to eliminate conflicting situations. The fastest way to do this is to look at the written records first, rather than to look at x-rays or casts. If a dental record indicates 3 crowns, when there are only 2 in the body found, then that must not be a match and you move on, right?

That, as it turns out, has a lot to do with the honesty of the dentist in question! When attempts were made to match teeth to an individual's dental records, it turned out that some of the dentists were found to have committed acts of insurance fraud! They thought why charge the insurance company for 1 crown when you can charge them for 2? The dentist would then charge the patient for her/his share of the single crown, and then keep the insurance company's payment for the non-existent 2nd crown.

What might have started as a seemingly small insurance scam, perhaps with none the wiser, actually turned out to be a crime of horrific proportions, as it made identification of the victims of 9-11 a nightmare and made the tragedy even worse for the victim's families by making them wait even longer to know if their loved one had lived or died. Although it is true that a great tragedy can bring out the best in people, it can also sometimes bring the dark side of people's actions, even past actions, into view.

undamaged, with the gums still appearing pink, and the teeth still white. Forensic dentists can also tell age solely by analysis of teeth. **Why would a dentist be able to tell your age? Do we get all of our teeth at once? Have students fill out the worksheet and guess (or remember) what age their teeth come in, check it as a group, and then discuss how they think that knowledge could be used by investigators to identify someone's age.**

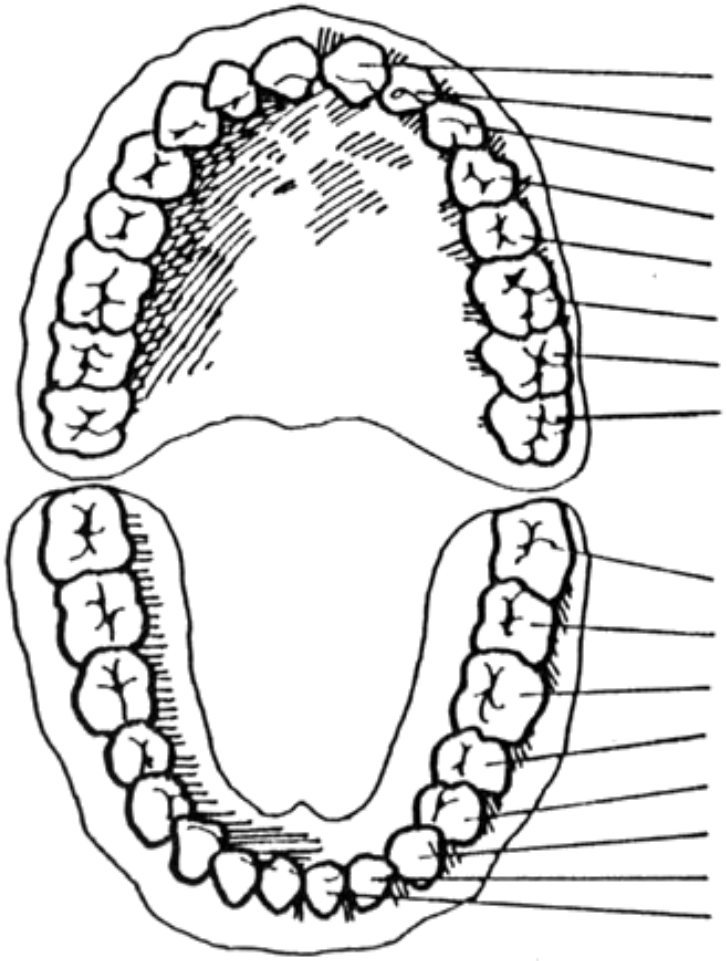
Answer Key



Your Best Estimate

Student Name:_____

Group Answer Check

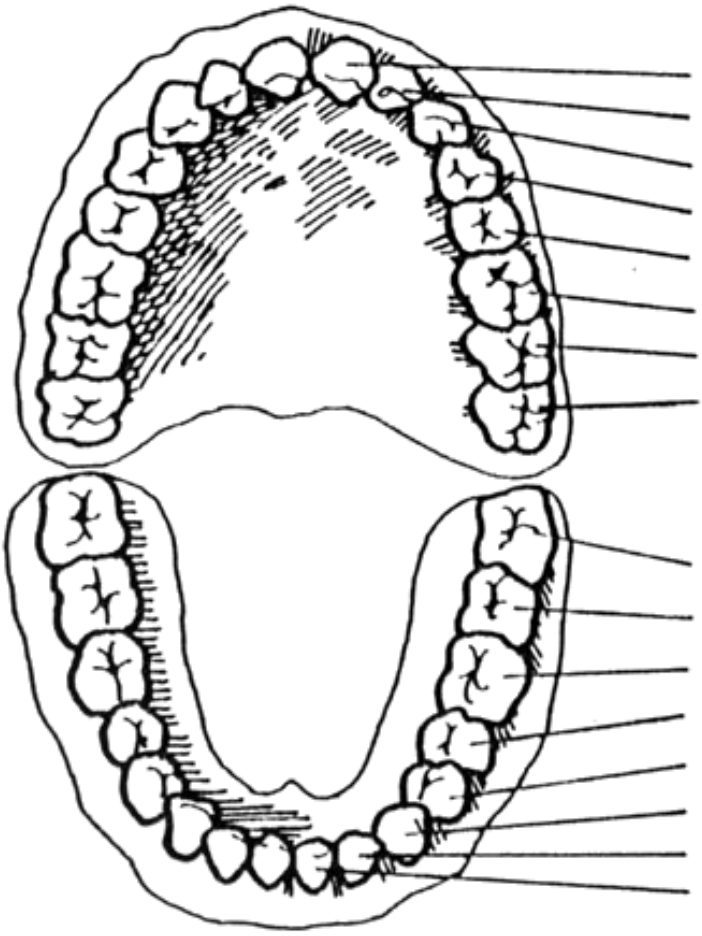


(Upper teeth)

central incisor	years
lateral incisor	years
cuspid	years
first bicuspid	years
second bicuspid	years
first molar	years
second molar	years
third molar	years

(Lower teeth)

third molar	years
second molar	years
first molar	years
second bicuspid	years
first bicuspid	years
cuspid	years
lateral incisor	years
central incisor	years



(Upper teeth)

central incisor	years
lateral incisor	years
cuspid	years
first bicuspid	years
second bicuspid	years
first molar	years
second molar	years
third molar	years

(Lower teeth)

third molar	years
second molar	years
first molar	years
second bicuspid	years
first bicuspid	years
cuspid	years
lateral incisor	years
central incisor	years

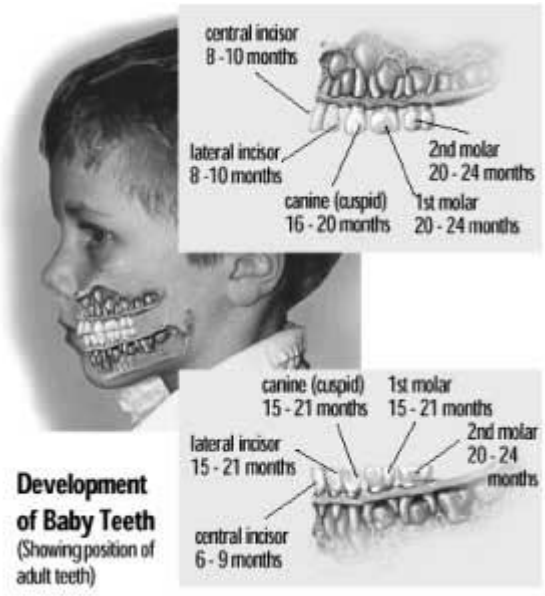
A Bite of History

The first forensic dentist in the United States was during the Revolutionary War, it was none other than Dr. Paul Revere (he of the famous ride) who identified the body of Dr. Joseph Warren, a revolutionary soldier for the British in 1775 through a bridge (a dental device) made of silver and ivory that he had constructed two years previously.

Dental evidence was first accepted in the United States court in the Webster - Parkman case. Dr. J.W. Webster allegedly killed someone on Nov., 23, 1849 in Boston charred fragments of mineral teeth fused to gold were recognized as those of the victim by Dr. Nathan Parkman. This evidence was enough for the jury to convict Dr. Webster of murder and he was hung.

Dental Disasters

Forensic dentists play an important role in identifying the remains of victims from mass disasters, such as those in the 1995 bombing of the Oklahoma City federal building. **How could a dentist help identify a body?** Dentists from across the country helped identify 25% of the human remains from that disaster. In a similar case, dentists helped identify many of the victims from the 1994 crash of American Eagle ATR 72 in Indiana. Even though only 9% of the victims' teeth were recovered from the crash, those teeth were used to identify half of the victims.



Bite mark analysis is somewhat newer but is gaining acceptance as a forensic tool. Bite-mark analysis is extremely complex, with many factors involved in a forensic dentist's ability to determine the identity of the biter.

The movement of a person's jaw and tongue when he or she bites contributes to the type of mark that is left. Depending on the location of the bite, it's not typical to find bite marks where both the upper and lower teeth left clear impressions -- usually one or the other is more visible. **Why wouldn't bite marks be equal? Do you ever press harder with your upper or lower teeth?**

Forensic dentists take measurements of each set of teeth and record it. They use scales to accurately depict the orientation, depth and size of the tooth marks. The photos are then magnified, enhanced and corrected for distortions.

A forensic dentist can tell a lot about the teeth of the biter based on the bite mark. **Why do students think that is? How could you tell something about teeth from a bite mark?** If there's a gap in the bite,

the biter is probably missing a tooth. Crooked teeth leave crooked impressions, and chipped teeth leave jagged-looking impressions of varying depth. Braces and partials also leave distinctive impressions.

They then compare transparencies of the mold with those of the bite-mark cast, and photos of both the bite mark and the suspect's teeth are compared to look for similarities. Once teeth impression are taken from a suspect these can be compared (in a blind test preferably) against the bite mark data and matched for up to seventy-six comparison factors. These include whorls, indentations, chips, abrasions, striations, distances between cuspids, tooth width and thickness, alignment and mouth arch.

The Effective Detective has seen many cases, ranging from the bizarre to the ridiculous, where bite mark analysis has proved fruitful in the pursuit and incarceration of villains, (**Where do students think it night help? What could get a criminal caught?**) such as the burglar who left a piece of chewing gum with a nice set of perfectly clear tooth marks, behind him at the scene of the crime. His gum chewing habit got him locked away!

Taking a Bite Out of Crime

To have Probationary Gumshoes become handy at the science of forensic dentistry the Effective Detective wants them to get a bit of practice at making good impressions.

Materials:

- Small Styrofoam plates (1 per student)
- Permanent Markers (1 per student)
- Rulers (1 per student)
- Some kind of semi-soft cheese or candy (small chocolate bar, Laffy Taffy, circus peanuts, AirHead, etc.)
- Overhead Transparencies (Cut into fourths)
- Timer
- Medical Disposable Gloves

Distribute Styrofoam plates and permanent markers to each student Instruct students to bend the plate in half so that the top of the plate is on the inside. They need to label one half with "maxilla" and one half with "mandible". Demonstrate how to make a bite mark impression on the plate.
Students will need to put the folded plate into their mouth as fall as possible and bite down on it to make a good impression. They should not bite too deep as to break through the plate. * *Students may need to cut their piece of Styrofoam so that they can fit the entire thing in their mouth to get a good impression.*
Provide each student with a piece of clear transparency or clear thick plastic and a permanent marker. They will need to place the plastic on top of their impression on the plate and use a permanent marker to trace the dental pattern onto the plastic as accurately as possible.

Have students unbend the plate and use a ruler to make the required measurements for width and depth of the impressions on both jaws. They will also need to note any unique characteristics they observe, such as slanted teeth, spaces, evidence of braces, etc. Have them study the teeth impressions and compare it to their dental worksheet. **Do they already have any teeth that are supposed to come later?** Count the number of teeth in the top and bottom impressions. **What other characteristics of the impressions do they notice?** Compare the top teeth impressions to the bottom. **Are there teeth missing, spaces, chips, or special features? Do the teeth match up (top to bottom)?** Make sure they can see the difference even if it is slight.

Have students use a ruler to make the measurements needed to the nearest tenth of a centimeter and record their data in the table along with any notes regarding unique characteristics they observe in their teeth, using the correct dental terminology for each tooth, ex. missing lateral incisor, and referencing their worksheet for help. Make sure they use a ruler to measure. Accuracy in measurement is CRUCIAL; therefore, you may want to review this technique with them.

These may be collected into a "dental database" in a binder or other system students develop. **If possible, have students compare different age groups of bite marks, ex. a toddler bite mark vs an adult bite mark.**

Case File Challenge:

WARNING: Since this activity involves possible actual contact with bodily fluid (saliva), please have students wear gloves and make sure that each sample is placed in a sandwich bag. This provides a good opportunity for discussion of why actual Crime Scene Investigators and Effective Detectives wear gloves and seal evidence as well, ex. not to compromise evidence and not to catch any diseases or poisons themselves.

Practice: Give each student group a sample of cheese or chocolate or candy to match up with their Styrofoam or transparency student teeth impressions. Make it easy the first time you do this by giving each lab group an impression from an actual student in that group. Note: It may be easier to keep track if you assign each student in your class a number, without telling them, and label their bagged samples with that number when they turn them in. Keep a master list and then you can double check student work by referencing the number and the name.

Crime Scene Connection:

1. Have students determine if they can easily match teeth to bite marks in a piece of chocolate or a circus peanut (or other impressionable candy such as Laffy Taffy or AirHeads) such as the one left

behind at your crime scene. Have each subject bite down on a small chocolate bar or circus peanut; label the top and the bottom impressions. Instruct students to gently bite into each piece of candy in order to make an impression, but not too hard to bite it in half.

2. Have students seal their impression into a sandwich bag. (Have students wash their hands after this.)
3. Next, have students study the impressions and count the teeth. Make note of other characteristics such as chips, spaces, or crooked teeth and compare to the plates in their database.
4. Have students give their carefully labeled impressions to another group. They will get another group's impressions to analyze. Once students have practiced have them retrieve the sample found at the crime scene from the "evidence locker." Can they find a match in their dental record database? Whose impression is it? Come to a consensus as a group.
5. If you would like to challenge a particular group by giving them a second sample, have them check all the Styrofoam impressions before they could possibly deduce who the culprit of the crime was. Adding a twist to the mystery could involve getting another teacher or adult to bite into chocolate and then contribute an impression that mysteriously turns up in the mix of student impressions. Have fun with it!

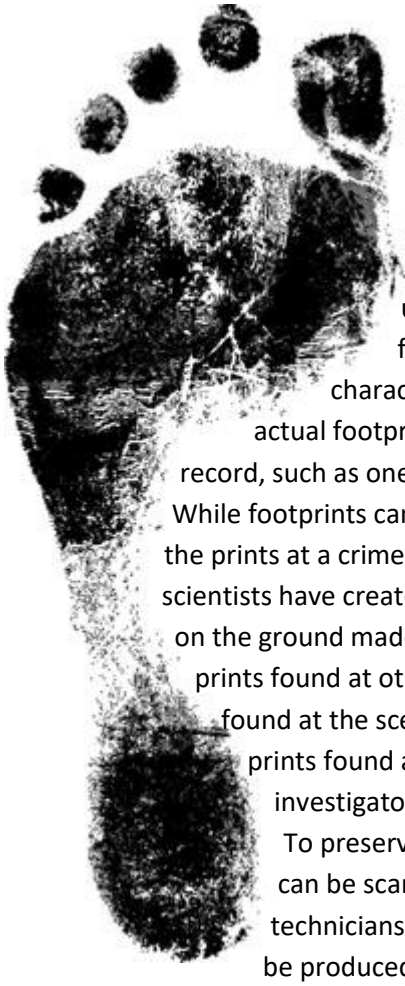
Have students write at least 4-5 reasons for choosing the person they did. Remind students to examine alignment, spacing, chips, missing teeth, special features, etc. when defending their choice. Each group will then report out their findings to the class, presenting their choice and reasons for choosing their sample that most closely resembles the case file evidence. State at least 3 reasons why other samples were not good choices.

Discuss with students what they've learned. How can bite marks be used to help solve crimes? Who has sharper teeth, young people or old? Why? Can this help you determine the probable age of the criminal? Why might teeth often be a better identifier of people than fingerprints?

Name:			
Jaw	Width Measurement	Depth Measurement	Unique Characteristics
Maxila (upper jaw)			
Mandible (lower jaw)			

Name:			
Jaw	Width Measurement	Depth Measurement	Unique Characteristics
Maxila (upper jaw)			
Mandible (lower jaw)			

Name:			
Jaw	Width Measurement	Depth Measurement	Unique Characteristics
Maxila (upper jaw)			
Mandible (lower jaw)			

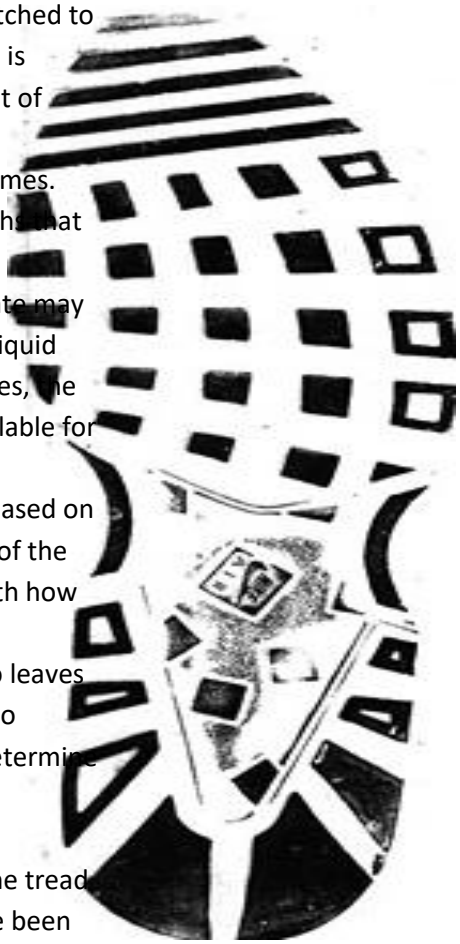


Leaving an Impression: Footprints

For years, criminal investigators and forensic scientists have used fingerprints to determine identity. More recently, footprints have been discovered to be an equally reliable identifier. Every person's foot has a unique set of ridges that make up a print unmatched by any other human being. As with fingerprints, the footprint's pattern is a unique characteristic that can pinpoint any one particular person. An actual footprint can be checked and matched to an existing print on record, such as one from a birth certificate.

While footprints can be used as a method of forensic science, most often, the prints at a crime scene do not come from a bare foot. To compensate, scientists have created methods of identifying shoe prints. The indentations on the ground made by any shoe can be studied, recorded, and matched to prints found at other locations. Therefore, if one set of shoeprints is found at the scene of a crime, it can be compared to another set of prints found at a separate crime scene. A matching print tells investigators that the same person was involved in both crimes.

To preserve the prints, detectives take detailed photographs that can be scanned into computers for analysis. In many cases, technicians will make a casting of the print so that a duplicate may be produced. The casting process involves pouring a dense liquid into the actual shoe imprint and allowing it to set. After the liquid solidifies, the casting can be picked up as one piece so that an exact replica will be available for future reference.



Forensic scientists can also make other determinations about a suspect based on their shoe print. The size of the shoe allows them to estimate the height of the person in question. By comparing how deep the print is in connection with how solid the soil was and whether or not the ground was damp at the time, investigators will also have a better idea of the weight of any person who leaves a footprint behind. By the distance between the steps they may be able to estimate how fast they were moving. All of these methods can help to determine the criminal's identity.

The analysis of footwear can place a person at a crime scene, either by the tread marks left in a footprint at the scene, or via trace evidence that may have been caught up in the tread of the shoes. A crucial part of investigative footwear analysis for our experts is that the shoe soles indicate a person's unique walking

style. For example those with high arches or those whose feet 'roll inwards' will have unique wearing pattern on the soles of their shoes.

The bones of the feet can tell a lot about a person. What do feet reveal about a person's height? Forensic anthropologists team up with law enforcers to help solve crimes. Bones of the feet can reveal an interesting fact about an individual. Let's combine math with forensics to see how. **As they complete this project, have students create a spreadsheet of class members, listing the individuals name, height, and foot length.**

Your body is a remarkably coordinated system made up of many, many parts (206 bones, 589 muscles, and over one billion nerves), each with a unique relationship to every other part. This activity explores a unique connection between them.

Materials:

- 7 foot pieces of rope (depending on student height), knotted on one end
- Hair clips or binder clips
- Meter/yard sticks or fabric tape measures
- Vanity mirrors

Probationary Gumshoe (Student) Procedure:

Begin by removing your shoes. Put the knotted end of the rope at the edge of your heel and measure the length of your foot from heel to toe—use a clip to mark this length on the rope. This is your own personal foot‖ measurement.

Now with a group member or your partner's help, use the same piece of rope and the —foot‖ you just marked to measure the distance from your elbow to your wrist (beginning again from the knotted end). It should be the same as the length as their foot.‖ Follow this same procedure twice more to measure:

• The distance around your clenched fist.

• The height of your head from your chin to the top of your skull.

(You should find that they're all about the same length.)

Now that students have a standard measurement, measure out 7 more —feet‖ on their rope and mark with a clip. (Older students can do this by measuring their foot‖ on a yard stick and then multiply that length by 7 while younger students can simply accordion fold the rope so they have a total of 7 —foot‖ lengths.)

Note: Multiplying the length of the foot times 7 is usually a close approximation for adults and kids that don't have a lot more growing to do. For younger kids, multiplying by 6 works better. (For really young children, it doesn't work at all.)

Now have students compare this new distance to:

• Their total height, from the floor to the top of their skull.

• The entire width of their out-stretched arm span.

(They should find that they're all about the same length.)

• This part is slightly less reliable, especially for children, but half of this larger measurement should be roughly equal to the distance from the tip of the nose to the tip of the middle finger (when arms are outstretched). On adults this measure should also be roughly equal to a yard.

Using the rope again (this might be a little awkward, but it‘s part of a large sequence) have students measure:

• Twice around the base of their thumb, then compare that to the circumference of their wrist.

• Twice around the wrist, which should equal the circumference of their neck.

You can skip this measurement depending on the age and behavior of the kids.

• Twice around the neck (on an adult of normal weight) should equal the circumference of their waist.

• The distance from the outside corner of their eye to the corner of their nose on the same side will equal both the height of their ear, and the width of their mouth.

What is going on?

This experiment is a glimpse into the field of science known as Forensic Osteology, or the study of bones. It is through the use of Osteology (how bones are formed, interact, age, and change over time) that Physical Anthropologists are able to analyze human remains. A person‘s individual proportions are so unique that this style of relating is the basis for forensic reconstruction, such as seen on television where they take bones and figure out what someone may have looked like. Using a person‘s foot, the total height of the person in question can be estimated, and if the skull is present, the measurements you just took can be used to reconstruct the shape of all the cartilage and soft tissue which is likely to have decayed.

Variation: Have some adults remove their shoes and measure their height.

Measure the length of the adult's left foot from the wall to the tip of the big toe.

Examine the numbers. Do you see a pattern?

Divide the length of each person's left foot by his/her height. Multiply the quotient by 100. What do you get? You may also want to use the calculator for this activity.

The results of your calculations should be about 15, illustrating that the length of a person's foot is approximately 15 percent of his or her height. Find out the approximate height of each of your classmates by measuring their foot and charting it on a spreadsheet. Use this proportion for your calculations: 15/100 = Length of Foot/x (person's height)

When a forensic scientist has the length of a foot, the forensic scientist will be able to approximate the height of the individual. This works best on a full grown individual for the ratio of body parts is slightly different in growing children.

Making Tracks

Using their observation skills, students will identify and compare footprints and shoe tracks placed at various stations around the classroom Crime Investigation Lab.

Materials Needed:

- Paper

- Clipboards (optional)
- Ruler, one per student
- Pencil, one per student
- Plaster of Paris (or dental stone),
- mixing container,
- water,
- paper clip,
- cardboard strips

Image Credit: JIM VARNEY/SCIENCE PHOTO LIBRARY. http://www.sciencephoto.com/media/222197/enlarge. All Rights Reserved. Copyright 2012.

1. Prior to the activity, collect evidence from the "crime scene case files" (a track or ink print of a track) and several different shoes with interesting tread marks for the groups to work with and try to match up.
2. Option: Use a shoe with an interesting tread to create tracks in sand or prepared (cleared and loosened) soil and take a picture for your evidence file. If needed the shoes can also be pressed in to Model Magic or Sculpey Clay (and baked) to create a reusable track from your crime scene case files for students to compare with. Along with the shoe print, include some bare foot prints, if you wish.
3. Set up the sand-filled trays and plaster cast materials for students to create shoe or foot casts once they have identified the different shoe tracks from the crime scene case files.
4. Provided each student with a student data sheet and a ruler. Practice measuring techniques with students.
5. Have students rotate to each station and record the type of shoe identification and description (ex. athletic shoe or boot, large, small) on their data sheet. Leave at least 20 minutes to complete the plaster cast activity.
6. Have students make a plaster cast of a shoe print that they have selected.

Casting Procedures:

1. Carefully clean the track of twigs, leaves, and other litter (if naturally occurring) or press the shoe into the prepared sand in the tray. Tracks make a better impression if the sand is prepared by wetting it with water from a spray bottle. Fingers should be used to gently turn the sand to ensure all the sand in the area of the track is moist.

2. Have students press a circular band firmly into the ground or sand tray so that the track is surrounded by the plastic or cardstock.

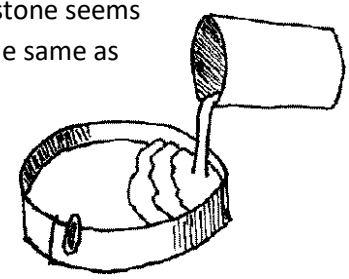
3. Mix about 1.5 cups of plaster in the pitcher or bowl, adding water slowly until it is about as thick as heavy cream (it should flow smoothly off of the stir stick). This should be done at the site of the track as the plaster will begin setting quickly in the bowl.

4. Pour the plaster carefully into the mold (as close to the track as possible to avoid obliterating the track, it's evidence!) until the plaster is about one inch above the ground. Allow the plaster to harden at least fifteen minutes before lifting it out of the track. If soil is moist, hardening may take longer.

5. Once the cast is hardened, students lift it out of the track and remove the plastic band. Once the plaster has completely dried, the track can be carefully cleaned of soil or sand using a soft brush.

6. The track cast can be preserved by applying a coat of spray enamel in two or three light coats, allowing each coat to dry thoroughly before adding the next. Two or three coats of acrylic spray can be added for additional protection, if the track is to be handled frequently.

You may not need the cardboard strip, although it is recommended to make a thick cast, especially when using plaster of Paris, which can break and needs the extra thickness to make a more sturdy cast. You can also add dry twigs, wire, or string to the plaster cast to reinforce it. If you use dental stone, you will not need to reinforce the cast as dental stone has a higher compressive strength than plaster of Paris. Less dental stone is needed to make a cast of the same size. Although dental stone seems more expensive, the fact that you use less per cast means it costs probably about the same as plaster.



1. Use your cardboard strip to build a wall around the track. Hold it in place with the paper clip. Be careful not to damage the track when you place this around it. Gently press the strip into the surrounding soil so the plaster will not run out from under it when poured.
2. Now mix the plaster. You should use about two parts plaster to one part water. For example, two cups of plaster mixed with one cup water. The consistency should be like that of pancake batter, or thick motor oil. It is recommended that you add the plaster to the water and begin mixing immediately. Plaster begins to set as soon as it comes in contact with water, so work quickly. If you use pre-measured quantities, add the plaster to the water all at one time, and begin stirring immediately, this will give you the best results. Stir it for 3 to 5 minutes and get rid of all the lumps.
4. Always tap the mixing container on the ground to remove any bubbles that may have accumulated in the mixture. This will give you a higher quality cast. You will see the bubbles rise to the surface.
5. Carefully pour the plaster into your pre-prepared mold. Do not pour the plaster directly into the track as this can damage it. Pour the plaster onto the ground next to the track and allow it to run into the track. Start with the finer details, such as claw marks, first. An alternative method is to pour the plaster

onto a spatula or spoon held low over the print and let it run off into the track. The utensil takes the force of the falling plaster, rather than the fragile track. Make sure you fill in all details of the track with plaster. Pour it relatively thick to make a good strong cast.
6. This is the time to add and reinforcing materials such as string, wire, or twigs.

7. Once they have finished pouring, let the track set for at least 1/2 hour. Some types of plaster may take longer to set.

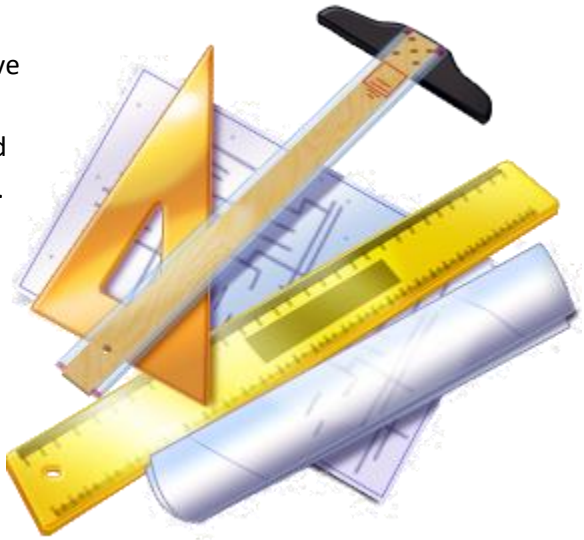
8. As the plaster dries, it will go from a glossy wet appearance to a dull matte appearance. It will give off heat as the chemical reaction takes place. After about 1/2 hour, you can gently touch the surface of the cast to see if it is dry or still soft. Do not press too hard as you could crack the cast. If it is dry, you can try tapping it gently with your knuckles. If it is firm and has a ceramic ring to it, then it is safe to pick up the cast. Pick it up by reaching underneath it and lifting it. Do not lift by prying under it with a stick. This could crack it. Have students try to lift it from opposite edges. If it is cast in mud, the mud may hold it firmly and they may need to carefully dig out some of the mud or soil from beneath the cast before lifting it.

Their cast is finished.

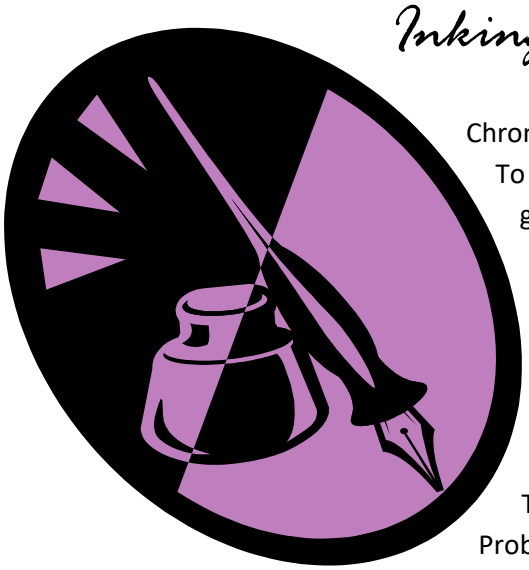
Allow it to dry for several days before cleaning it or painting it. Never wrap plaster casts in plastic bags as this prevents the moisture from escaping. When you clean a plaster cast, do not scrub too hard with a brush as this will erode away the plaster and take the details of the track with it. Plaster is soft and will eventually dissolve if left immersed in water. The best way to clean casts is holding them under running water and gently rubbing excess dirt away. Do not rub over the details of the track itself, but rather the areas around it. Scrubbing on the details of the track may sand them off. There will be some dirt or sand remaining on the cast. This is normal. If they used dental stone, they can scrub the cast and not lose detail as it is a much stronger material.

Measure It!

Once they are set and dried, give each group a track and have students apply the math skills they learned in the Forensic Osteology activity and see if they can measure the tracks and estimate the height of the person who left the tracks behind. Can they narrow down the list of people it might be and identify the maker of the track? Remember, multiplying the length of the foot times 7 is usually a close approximation for adults and kids that don't have a lot more growing to do. For younger kids, multiplying by 6 works better. Or, use this proportion for their calculations:
15/100 = Length of Foot/x (person's height)



Inking the Evidence with the Crime



Chromatography -- what does it mean to an effective detective?

To write with colors -- literally translated from its Greek roots chroma and graphein , chromatography was first developed by the Russian botanist Mikhail Tswett in 1903 as he produced a colorful separation of plant pigments.

But black ink is black ink, right? Maybe not! Even though the ink from different pens looks the same, it might actually be made of many different dyes. Probationary Dectives can separate the dyes in the ink from different pens to make different patterns.

The objective of this project as assigned by the Effective Detective is for Probationary Gumshoes to become familiar with how use chromatography, or the separation of a mixture into its various base components. The Effective Detective has a note from his evidence files written on some absorbent paper by someone using a felt-tip pen, one of those he needs the Probationary Gumshoes to test while he works on another case.

Materials:

- Absorbent paper (kitchen towel/coffee filters)
- Some felt-tip pens
- A tray filled with a little water (0.5 cm deep)
- A table
- A hand-written note

What you do

Teacher tip: Write a hand written note on absorbent paper with a felt tip pen, including a question mark with a clear dot. Collect several different types of felt tip pens, ex. different brands, but with the same color, to make it a bit more challenging. Ensure that the note contains an inky dot, like at the bottom of a question mark and make sure the strip has no markings on it, other than the dot. Option: If you want to have the mystery be a surprise for you as well, have a volunteer write the note before class using a selection from your collection of pens, but don't let them tell you which one.

1. Have students cut a strip out of the note. This strip should be clear of any ink except that of the dot. Leave 1cm space between the dot and the bottom of the sheet.
2. Take a clean sheet of absorbent paper. Draw three dots, using the three different felt-tip pens from the evidence case file (including the pen used to write your note).
3. Leave 1cm space between each dot and between the dots and the bottom of the paper (see image).
4. Pour a little water into a tray (0.5cm deep is enough).

5. Have students *lightly* dip the paper into some shallow water
6. Take your sheet of suspect dots, and your strip from the note, and dip them into the water. **Be careful** not to let the water hit the ink directly. This is why you need the space between the ink and bottom of the paper.
7. Hold the paper in the water for a few minutes and let the capillary action separate the inks into their various base colors. The water will rise up the paper in a column, separating the ink on its way. This should create a distinct pattern for each pen allowing Probationary Gumshoes to identify if a mark left at a crime scene came from a suspect's marker.
8. Compare the pattern from your tester sheet to the strip from the note. Which patterns match? Which pen was used to write the note?

Try using a range of different felt-tips. Do some colors work better than others?

What should happen?

As the dyes in the ink separate, a pattern forms.

As the water moves up the paper, some of the ink should move with it. Depending on the make-up of the ink, this could separate out into a number of bright colors. The pattern from the note should match a pattern created by one of the tested pens. This should be enough evidence to confirm which pen wrote the note!

How does it work?

Ready for the scoop on how paper towel chromatography works? When the paper towel is dipped in water, some of the water sticks to the paper towel and gets it wet. There's a force between the water molecules and the molecules in the paper towel. That's called adhesion. The water also sticks to itself. That's called cohesion. Both of these sticky forces - adhesion and cohesion - cause the water to travel up the paper towel, moving against gravity. When the water reaches the ink, it dissolves some of the dyes in the ink, and the dyes travel up the paper towel with the water. That's how you can see all the different colors that make up the ink and solve the mystery.

If it doesn't work for you

- It is important that the ink moves in a steady upward column only. If the dot itself is submerged in the water, then the ink will run and it will hamper your results.
- We use felt-tip pens because they are water soluble and so will separate out in water. If you're using a ballpoint pen, or a permanent marker, water is probably not the right solution. You might need to try methylated spirit. **Warning** this substance is poisonous. Please ask an adult to assist.
- Absorbent paper is essential. If you are trying this on ordinary paper then you are clearly too advanced for Yan and need to read onto the next section.

What's going on? Separating compounds

It is very hard to know how many components a mixture is made of, because the parts are impossible to distinguish separately. This is where chromatography can help. Chromatography, meaning color-writing, is a lab technique that can separate a mixture into its individual parts based on their chemical characteristics.

The idea behind this experiment's use of paper chromatography is that as the ink is carried up the paper by the water, the different dyes in the ink will separate depending on how much they interact with the paper.

This works because some molecules, (in this case, the ink dyes) are happier in the water, while others are more attracted to the paper. As the water moves up the paper, the molecules separate based on how much they like water, or paper. The separation creates a pattern that, in Yan's case, can be used to help identify the doughnut thief.

To catch a thief

Forensic scientists rely on chromatography to analyze fibers that are found in a crime scene. For example, if someone breaks into a house by smashing a window, there is a chance that some of the fibers from their clothing were caught on the smashed glass. If so, chromatography is used to reveal the dye pattern in the fragments, just like the pen ink in Yan's note. If the dye pattern of the crime scene fiber matches another sample taken from a suspect's clothing, then this evidence might be enough to help identify the intruder.

History Fact: In 1952 two British researchers, Martin and Synge, were awarded the Nobel prize for using paper chromatography to separate the amino acids in a protein.

Challenge: Have students use four of the tested markers to create a Effective Detective Mystery Pen challenge. Have the students test the four mystery markers and compare them to the samples they previously tested. Set up the challenge as a race to see which student team can be the first to correctly identify them.

FILE NO. 45780B

Liar Liar, Glands on Fire

The concept of a lie detector is centuries old. The ancient Chinese had a suspect chew dry rice while he was being questioned. **Why do students think they would do that? What could rice tell?** After questioning, the rice was examined. If it was dry, the suspect was assumed to be guilty. As was assumed then – and is currently supported by more recent evidence – the nervous tension created by lying slowed or blocked the flow of saliva. Thus, the dry mouth led to dry rice and a guilty verdict. There were similar practices in West Africa as well as other parts of the world.

Forensic Psychology Experiment:

Using magnetic resonance imaging machines, or MRIs, neuroscientists (brain scientists) have been able to determine that the human brain works harder when it tells a lie.

Have students put this discovery to the test by conducting a forensic psychology experiment wherein they will see if lying impacts the brain's ability to conduct a particular task. Have a volunteer hold out his arm perpendicular to his body, with his palm down. Ask him to keep his arm in that position while he repeats a series of phrases. Two will be truthful statements while one will be a blatant lie. After your volunteer says each phrase, push down gently on his arm, using the same force every time. Conduct the experiment on several more volunteers, and determine if there is a correlation between lying, and whether or not the brain makes the participants increase or decrease their resistance against your pushing down.

Wired Liar?

The lie detector, or polygraph, was invented in 1921 by John Larson. Today, most law enforcement agencies rely on the polygraph determine whether the suspects or the perpetrator is telling the truth for their alleged crimes. What looks like a very complicated machine with a lot of hanging wires is actually quite simple.

You hear about lie detectors all the time in tv show or real world police investigations, and sometimes a person applying for a job will have to undergo a

polygraph test (for example, certain government jobs with the FBI or CIA require polygraph tests). The goal of a lie detector is to see if the person is telling the truth or lying when answering certain questions.

When a person takes a polygraph test, four to six **sensors** are attached to him. A polygraph is a machine in which the multiple ("poly") signals from the sensors are recorded on a single strip of moving paper ("graph"). The sensors usually record:

- The person's **breathing rate**
- The person's **pulse**
- The person's **blood pressure**
- The person's **perspiration (sweat)**

Sometimes a polygraph will also record things like arm and leg movement.

When the polygraph test starts, the questioner asks three or four simple questions to establish the norms for the person's signals, called a baseline. Then the real questions being tested by the polygraph are asked. Throughout questioning, all of the person's signals are recorded on the moving paper.

Both during and after the test, a polygraph examiner can look at the graphs and can see whether the vital signs changed significantly on any of the questions. In general, a significant change (such as a faster heart rate, higher blood pressure, increased perspiration) indicates that the person is lying. See video @ http://science.howstuffworks.com/question123.htm.

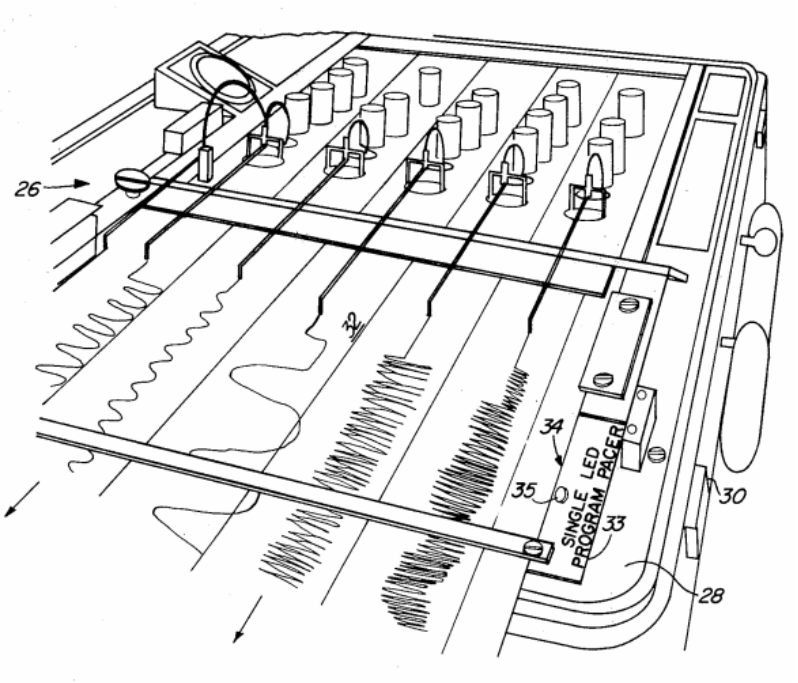
When a well-trained examiner uses a polygraph, he or she can detect lying with high accuracy. However, because the examiner's interpretation is subjective and because different people react differently to lying, a polygraph test is not perfect and can be fooled.

In this experiment, students will make their own lie detector and create their own polygraph process. Obtain a blood pressure monitor for home use at your local drug store or pharmacy. The rest is pretty basic and should be prepared and gathered by the experimenter.

Materials:

- A blood-pressure or pulse rate monitor
- A list of premade yes/no questions (about 10) of students choice to ask each of their test subjects (examples that are possible questions will be suggested below)

- At least 10 test subjects (it is best if it is random people or people they do not know too well; perhaps some kids in another group? Just remind them to make sure that they DO NOT know the answers to any of the questions they are asking!)
- Pen and paper
- A keen mind
- Optional: Stethoscope
- Optional: A partner
- Optional: A watch



Experimental Procedure

1. Have students prepare beforehand a list of about 10 numbered questions that they are going to ask each of their test subjects. Make sure they are 10 simple yes/no questions with no elaborate answers. *Suggestions are shown below.*

2. Find test subjects. Remind students that it is better not to choose the people who are close to them as they will most likely know the answers to the questions. That defeats the purpose of this experiment. A suggestion is to find students in a separate group. They are to question their test subjects separately.

3. Once their test subject has been seated, follow the instructions provided by the chosen blood pressure monitor or format. Most likely, it will require them to strap the cuff around the subject's arm. Have them do this.

4. Instruct the test subject to purposely pick questions to lie on without revealing to anyone what they are and that they should remember which ones they lied on for the conclusion of the test.

5. Have the testers start asking their prepared questions and observe the test subject's traits that seem to be out-of-place on certain questions. Perhaps they are fidgeting? Playing with their thumbs? Both of these are very likely signs of deception. Note their thoughts for each question. A chart is provided below as a guide.

6. When the subject is answering each of the questions, make sure to use the blood pressure monitor and record the rates. (OPTIONAL: If they are working as partners have one place the stethoscope on the subject's chest or if they do not have a stethoscope then have one partner place their index and middle finger on the subject's wrist to count their heart rate in beats per minute or rate it by speed and record it.)

7. At the end of the questioning for each subject, hypothesize on which questions you think the test subject is lying on based on your observed physical movements, traits, and blood pressure. The higher the blood pressure is, the more likely they are to have lied. At the same time, ask the test subject to write down on a piece of paper themselves the questions they actually lied on; no peeking!
8. Have students compare their hypotheses with their test subjects' responses and evaluate how many questions you got right out of 10.
9. Have students repeat steps 3-8 for all their test subjects.
10. Evaluate how well they did by finding number of questions they got right against the ones they got wrong.

Here is a sample list of possible questions of the type students may use in the experiment. Don't forget, students and the group are free to make up others and additional YES/NO questions.

1. Do you own a pet?
2. Did you grow up here?
3. Do you have any siblings?
4. Have you ever gone to *insert location here* ?
5. Do you know *insert person name here* ?
6. Have you ever had *insert food/drink item here* ?
7. Can you play any instruments?

SAMPLE of a chart for recording data:

Question #	Blood Pressure	Fidgeting?	Irregular vocals?	Other strange movements and notes
1				
2				
3				
4				
5				

….				
10				

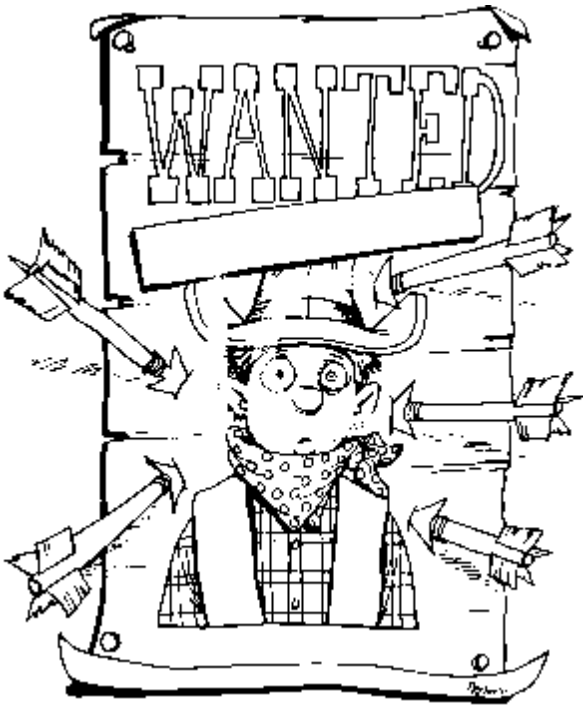
** Optional: Heart Rate can also be included in the chart if you have chosen to test that as well.**

Post Discussion:

- What are some examples of early practices that were done to determine who was lying?
- What were some of the earlier models of lie detectors?
- What does the polygraph monitor?
- How could they, as the polygraph user, tell if the person is lying?
- How accurate was their polygraph?

Wanted! Keeping an Eye on Crime

Being an effective detective is all about simplicity . . . making the most out of what you have. Your Probationary Gumshoes will get a kick out of creating their own Outlaw's personality.



Materials:

- White*, manila, or craft paper
- Colored paper for background
- Pencils
- Coloring materials, ex, Tempera Paint in flesh light, flesh dark, brown, black, green & brick red
- *Spray bottle filled with brown liquid watercolor if using white paper [to age it]

Note: If you have manila or craft paper on hand, this step isn't necessary but if you only have white paper, this is one way to give the paper an "aged" look. After they finish their drawing, have students fill up a spray bottle with water and add a bit of brown watercolor paint or food coloring. Students can adjust the color until they have the patina they're after. Place drawing inside a cardboard box (with one side cut off) and spray over the entire paper. When it dries, the paper will be ready for the next step, paint or coloring!

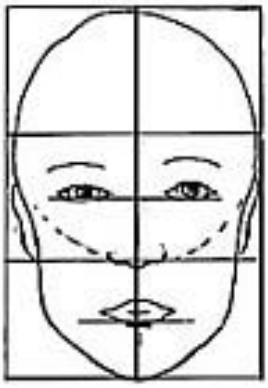
All about Proportions

The first step toward teaching students portraiture is explaining the proportions of the face. Proportions of the face refers to how large and small facial features and areas of the face are in relation to each other. There are basic rules that students can learn to capture the face in a realistic way. Once students have learnt these rules stylizing the various facial features and exaggerating areas of the face to create a character will become much easier.

The face is the feature which best distinguishes a person. Its features - the eyes, nose, mouth and ears - are where we see individuality in people. If students understand the basic components of these features drawing them will become easier and their drawings and paintings will only be better.

Before students can begin to fill in a face with its features they need to map out the face using a ruler and pencil to create a contour image. A contour image is a picture created using only lines, without any shading. The idea in this method is to "build up" the face with the basic face shape acting as a frame.

Egg Heads



For elementary school students have them measure the spaces as they go in order to correctly place the features.

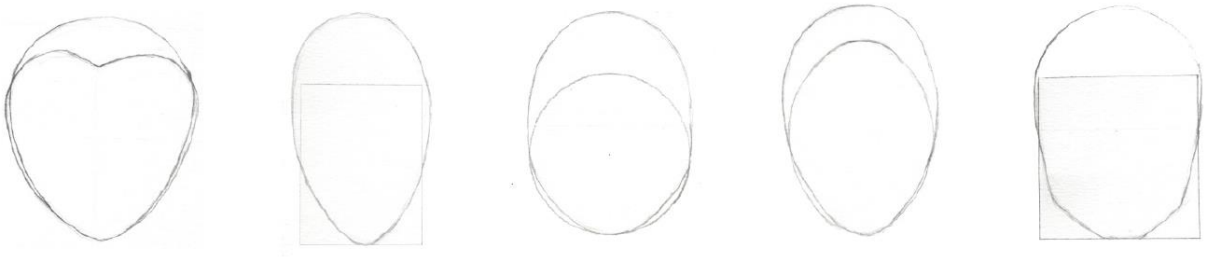
1. Have them draw the head as basically egg-shaped, with the eyes falling half way between the top of the head and the bottom of the chin.
2. The eyes themselves are separated by the width of one eye, in other words, a third eye should be able to fit in the space between the eyes they draw.
3. The nose begins between the eyes and extends halfway between the eyes and the chin. It is as wide at the nostrils as the inside of the eyes.
4. The mouth lies halfway between the bottom of the nose and chin, and is as wide as the center of the eyes.
5. The ears generally start at the top of the eye and end at the bottom of the nose.

Explain these basic proportions the students and have them look into a mirror to see this for themselves. Prompt them to notice the slight differences in their own face from these basic proportions. Give them pencils and paper, and have them attempt to draw a contour picture of their own faces using the basic proportions you have explained to them, a sample of how to do a directed line drawing of a Wanted Poster face is included. Option: If possible, have each student set a small mirror on their desk.

Shapely Faces

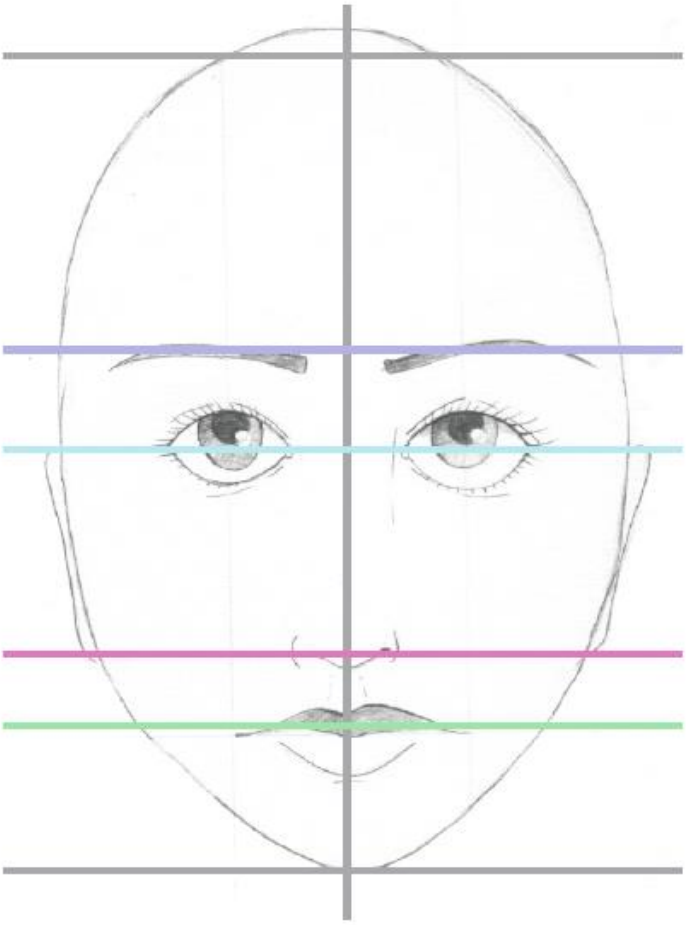
Older and more experienced art students can understand there are five basic face shapes- round, oval, square, long and heart. Although these shapes are simply general guidelines it is a great starting point in understanding the individuality in faces.

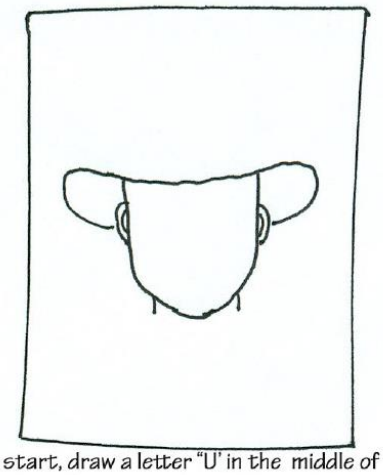
TYPICAL FACE SHAPES



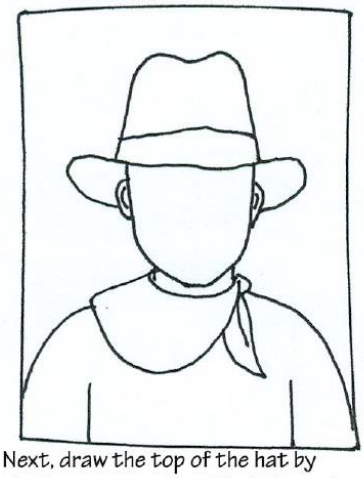
HEART LONG ROUND OVAL SQUARE

6. Have students start by choosing one of the face shapes and draw it on their page using light pencil lines.
7. Then have them use their rulers to measure and then *very lightly* draw two light lines- one to divide the face precisely in half horizontally and one to divide it precisely in half vertically.
8. Have them draw two eyes half way down the face, remembering that the size of one eye should fit between the two.
9. Remind them that when shading the eye leave a small white dot on the iris and the pupil to give the illusion that light is glistening on a moist surface. More advanced students can be reminded to co consider the direction of the light source when placing this highlight.
10. Have them use their rulers and draw a line one quarter of the way up between the center of the eye and top of the head. This is where the eyebrows generally sit.
11. Draw a line half way between the eyes and the bottom of the head, this is where the bottom of the nose sits. Students may simplify the shape of the nose by drawing three curved lines.
12. Draw a line which sits one third between the bottom of the nose and the bottom of the chin, this line is where the middle of the lips sit.

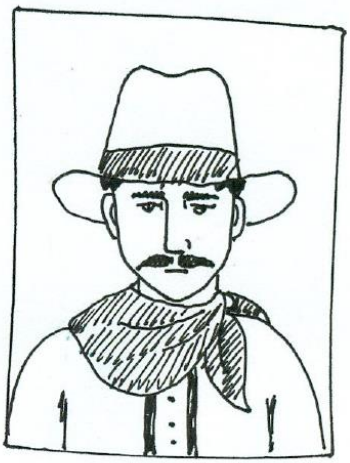




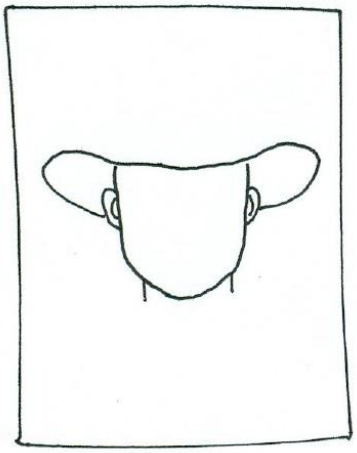
To start, draw a letter "U' in the middle of the paper. Leave room on top and on the bottom. Add ears. Place your pencil next to an ear and draw the brim of the hat. The brim line should touch the top of the letter "U" and curve around to the other ear.



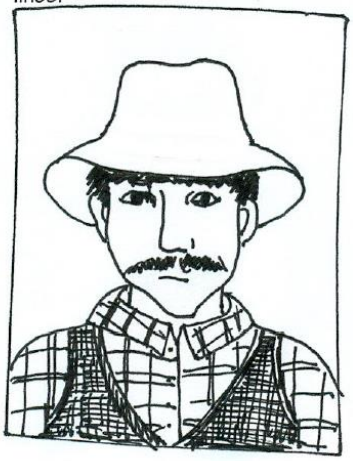
Next, draw the top of the hat by placing your pencil on the brim and making an upside down "U". Shape the hat as you wish. Draw two short lines for the neck, add a bandana and shoulder lines.



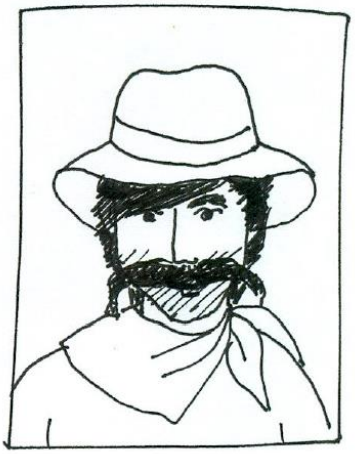
Finish your drawing by adding a face. To make the nose, draw an upside-down number "7". Then eyes, mustache and a mouth. Add hair and details to your shirt.



Here is another type of hat. Start the very same way as above but instead of adding the upside-down letter "U", make two angle lines starting at the outer most edge of the hat and drawing inwards a bit.



Next, draw the top part of the hat by placing your pencil on the angle lines and drawing an upside-down letter "U". Shape the hat as you'd like then add a band. Finish off your cowboy or cowgirl.



By keeping the drawing simple, you create more areas to paint. Don't color in your hair (as in the example). Your drawing should look like a coloring book-ready to paint!

WANTED!!!

DEAD OR ALIVE!

Adding a Touch of Color

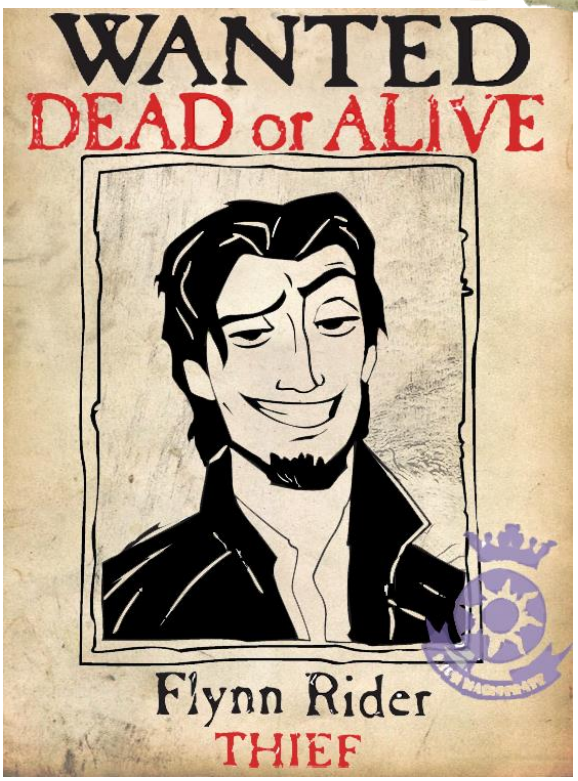
Now that they have drawn their portrait, it's time to fill it in! Students may use pastels, markers, crayons, paints, or colored pencils. If using paint, divide students into groups and set out a tray of tempera paints for each group. Mixing regular colors together can be done to create different values. If you prefer to have your students get the experience of mixing their own paints and learning about colors, that can be done too. For instance, to create a navy blue paint, have students add a squirt of black to regular blue. Students can either mix it up in plastic containers or use the existing bottle. To give red an added rustic punch, add a squirt of brown. Altering the paint this way establishes the mood students have in their paintings.

Option: Set out two trays of paint per group, one with a skin palette, with skin, hair, and eye colors, and the other with hat and clothing colors to make it easier for students.

Have them use a medium sized brush and paint the face, ears, and neck with a skin color. While the skin dries, they can paint the hat and clothing. After the paint on the face dries have them paint the eyes, mouth, and eyebrows. Instead of painting the nose immediately have them wait until the outlining step to do this. Have them set out the small amount of white paint for the whites of the eyes.

The final touches...

Once everything is painted, set out small tubs of watered down black paint and small brushes, or black markers, or oil pastels. Have students go over all the original pencil lines as well as adding eyelashes, nose lines, mustache hairs, texture in their hats, etc. Tell students this is a great time to add lots and lots of details.



Then have students very very carefully use a ruler and rip the edges of the paper, giving it an authentic tattered look of a wanted poster that's been hanging up in the Effective Detective's office for quite a while.

Once they've finished, give each student an additional strip of paper to go over or under their portrait. Have the students create a name for their villain and a short biography (is there a reward?) and a wild name like Squint-Eyed Gert or Wee Wild Billy McGillicutty!

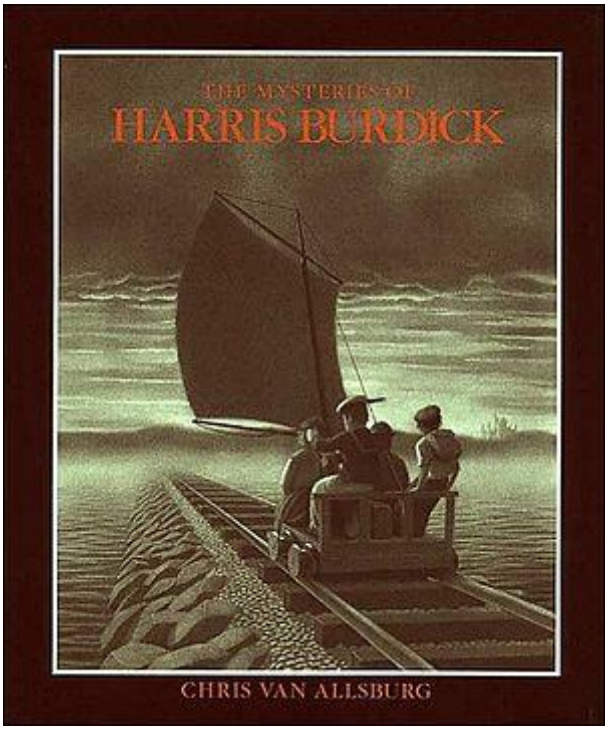
Making Western lettering...

Have students use pre-cut strips of paper and a pencil and a ruler have students use five lines, two near the top of the strip and two near the bottom one and one line through the middle. Have

students practice their measuring skills. Each letter will have a small "rectangle" where it touches the top and bottom line. That's why there are two lines at the top and two lines at the bottom. They will form a rectangle once the horizontal lines are added. Have students sketch in the letters lightly, making sure they stretch all the way across the whole strip and where each letter touches the top and bottom lines, have them draw a rectangle. Have them add double lines along each letter to make them thick and then color them in with a blank marker.

It Was a Dark and Stormy Write...

Mysteries are a great way to hook students into writing about fictional happenings and an Effective Detective sees enough weird and wacky happenings to populate an entire library of characters!



Materials:

- A copy of *The Mysteries of Harris Burdick*
- Paper
- Pencils
- Imagination

Introduce students to the idea of mystery and have a class discussion about mysteries that your students have read, written, or tried to solve. Explain to students that today they'll be learning about *The Mysteries of Harris Burdick* and trying to solve the mysteries within the book. But the puzzles, the mysteries, presented by these drawings, are not what we are used to. They are not solved for us, as in the final pages of a book or a film's last reel…

13. Begin reading the book aloud to your students, beginning with the Introduction. The book begins with a fictitious introduction, informing the reader of the literary legacy, or lack thereof, of a Mr. Harris Burdick. After showing samples of his work to a children's book publisher, Burdick has been hired. However, before Burdick is able to bring the complete copies of his fourteen stories and related pictures, he goes missing. What the publisher is left with are single titles, captions, and images from Burdick's stories, or what also becomes known as the mysteries of Harris Burdick. After finishing the Introduction, read page-by-page through the book, pausing to show the pictures on each page and reading the title and caption that go with each image. Option: You may choose to display large, poster-size images from the book, which are available in the portfolio edition of *The Mysteries of Harris Burdick*.
14. Allow students to comment about each picture and caption as you read the book aloud to help spark their imagination for the writing they will be doing. After reading *The Mysteries of Harris Burdick* to your students, engage them in a brief discussion of the book's context. Draw their attention to the fact that the book is meant to function almost as a sourcebook for writing ideas.

Tell them that many writers create their own lists of ideas to help them begin stories, like a detective with a notebook full of clues, only these are clues to stories. Sometimes writers [and detectives] carry notebooks around and write down ideas when they come to them, so that when they sit down to write, they have many ideas to choose from.

15. After your discussion explain to students that their latest assignment as Probationary Gumshoes is to unravel the mystery from one of the pictures in this story. They must write a creative mystery that goes with an image of their choosing from the book.
16. Tell students that once their stories are written, they will be read aloud to the class and the other students will be responsible for figuring out which image from the book their story represents.
17. To prepare for writing, introduce students to the Mystery Cube idea organizer. This tool will be used to help students develop outlines for their own mystery stories.
18. Complete a Mystery Cube as a class to familiarize students with the tool and what is expected of them. Allow the class to choose one of the images in the book (and the caption that goes with it) for which to create the class Mystery Cube. Then, using the class Mystery Cube as a guide, write a short mystery as a class. **Hold a discussion about why exactly it is that these images and ideas are so stimulating to readers. What interests us about the scenarios Van Allsburg sets up? How can we as writers bring the same kind of intrigue into our own stories?**
19. Allow time for students to peruse the images in the book and/or the larger portfolio images to read the captions and decide on which image they'd like to write about. After students have decided on an image to write about, they should begin brainstorming ideas for their story and using the Mystery Cube Planning Sheet to flesh out their ideas. Option: Have your students use the captions as the first line of their stories.

20. Have students organize their thoughts by filling in the information for each side of the cube. Since space on the cube is limited, they will need to summarize their information. Unlike traditional prewriting webs or charts, filling out the Cube Creator is more like completing a puzzle. It challenges students to organize information, creating a comprehensive summary of their story by completing the cube.
21. Students may begin writing their own mystery story. They should use their Mystery Cube for guidance as they write. Note: Much younger children who are not yet

experienced writers may still participate in the creative writing process. Instead of asking them to write stories based on ideas the class comes up with, you may want to have very young children tell the stories out loud. You can take dictation or have students sit in a circle and creating a story out loud about one of the pictures, with each child adding a detail to the one before. Teachers can record the stories that younger children invent about these pictures and read them out loud later.

22. Once students are done with their first draft of their story, they may begin self-editing and peer-editing. They may use the Editing Checklist for Self- and Peer Editing to assist them and a partner when they are ready to edit.
23. Allow students to finish their self-editing and peer-editing from the previous session, using the Editing Checklist for Self- and Peer Editing. After their stories have been edited by themselves and a peer, students may begin writing their final draft of their mystery story.
24. Their final draft should be completed prior to the next session. When students have completed their final draft, they should turn in their rough draft, completed Editing Checklist for Self- and Peer Editing, and their final draft for the teacher to check for completion of all of the steps. Return each student's story to him/her.
25. Finally, Display the images from *The Mysteries of Harris Burdick* in front of the class if you have poster-size images, or display one or more copies of the book. Organize a class read-aloud where each student is given the opportunity to read his/her story aloud to the rest of the class. Allow the other students in the class time to discuss/comment on each story and decide which image/caption from *The Mysteries of Harris Burdick* it belongs to.

Options:

- Have students submit their stories to the Houghton Mifflin's *Harris Burdick* Book Site [http://www.houghtonmifflinbooks.com/features/harrisburdick/index.html]. New stories are posted each month, and periodically writers are selected at random to receive books autographed by Chris Van Allsburg and other Burdick-inspired items.
- A fun way to bring older and younger students together might be for a class of older students to collaborate on creating a "mysteries" book of their own, and then to present it to a lower-grade class and ask for help inventing stories to go with the scenarios.

MYSTERY CUBE

Mystery Cube created by:

.

Cut along the outside edges of your Mystery Cube. Then, fold along the dotted lines, making sure that your typed information stays on the outside. Tape the sides together to make a cube.

Author's Name: _____ Date: _____

Peer's Name: _____ Date: _____

Editing Checklist for Self- and Peer Editing

Directions: Edit your written work using the Self-Edit columns, fixing any errors you notice. Then, have a peer complete the Peer Edit columns while you observe.

	Self-Edit		Peer Edit		
	Checklist Items	After completing each step, place a check here.	Checklist Items	After completing each step, place a check here.	Comments and Suggestions
Punctuation	I read my written piece aloud to see where to stop or pause for periods, question marks, exclamation marks, and commas.		I read the author's piece aloud to see where to stop or pause for periods, question marks, exclamation marks, and commas.		
	Quotation marks are included where needed.		Quotation marks are included where needed.		
Capital Letters	I checked for capitals at the beginning of sentences.		I checked for capitals at the beginning of sentences.		
	Proper nouns begin with capital letters.		Proper nouns begin with capital letters.		
Grammar	My sentences are complete thoughts and contain a noun and a verb.		Sentences are complete thoughts and contain a noun and a verb.		
	I don't have any run-on sentences.		There are no run-on sentences.		
Spelling	I checked spelling and fixed the words that didn't look right.		Spelling is correct.		

Author's Name: _____ Date: _____

Peer's Name: _____ Date: _____

Editing Checklist for Self- and Peer Editing

Directions: Edit your written work using the Self-Edit columns, fixing any errors you notice. Then, have a peer complete the Peer Edit columns while you observe.

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	Quotation marks are included where needed.		Quotation marks are included where needed.		
Capital Letters	I checked for capitals at the beginning of sentences.		I checked for capitals at the beginning of sentences.		
	Proper nouns begin with capital letters.		Proper nouns begin with capital letters.		
Grammar	My sentences are complete thoughts and contain a noun and a verb.		Sentences are complete thoughts and contain a noun and a verb.		
	I don't have any run-on sentences.		There are no run-on sentences.		
Spelling	I checked spelling and fixed the words that didn't look right.		Spelling is correct.		

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Under Review

Math Detectives

Calling all Probationary Gumshoe math detectives! Mysteries are popping all over town, and our chief sleuth The Effective Detective needs your help to crack each case. Have students practice their mental math logical reasoning skills, whole number operations, fractions and ratios, combinations and probability, geometry, measurement and time by solving some of the Math Maven's mysteries at http://teacher.scholastic.com/maven/cafeteri/index.htm. Note: The mysteries are separated by topic and difficulty and there are printable versions of each.

Clue!

It's a whole class review, but only two students compete at a time.
Two students come up to the board but face the class. The Teacher writes a term such as a concept that's been taught or a vocabulary word, etc. on the board behind them. They then take turns calling on a student to give them a one-word clue to help them guess the word. They take turns calling on students until one of the two at the board is able to guess the word. The student in the "audience" that gave the final clue then gets to come up to the board and takes the place of the student who was not able to guess the answer.
It's fun because the students in the audience really have to think about the concept to be able to give a good enough clue so that the student can guess it correctly, and the students at the board have to be able to process the different clues they are given so that they can give the right answer.

Mystery Points

One really fun game that works for reviewing any subject is to divide the class in two teams & assign mystery point values to each question or problem. For example, make 2 matching sets of point cards, such as 5 pts, 79 pts, 1000 pts, 2 pts, 500 pts, etc for each team. Then scramble each set of cards before starting the game, team #1 's first correct answer might be worth 79 pts, team #2's question might be worth 1000. Have a score keeper write the points earned on the board. Students have a lot of fun adding up the total points at the end of the game.

FILE NO. 45780B

EVIDENCE LOG

CASE # _____

Date:

Name of Investigator:

List Item(s):

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Physical Description(s):

Location(s) Found:

Observations:

SEALED BY: DATE:

EVIDENCE

TO BE OPENED BY AUTHORIZED PERSONNEL ONLY

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Sources and Resources:

This lesson plan is a small window into the vastly intricate world of Forensics. We hope it will stimulate further exploration by students, and instructors, into the world of experts in the field, expand the boundaries of our thinking about the world, make students laugh, and then make them think, make us more observant, and stimulate our imaginations. In the construction of this lesson plan we have been guided by, and recommend the following resources among many others:

- "A Teacher's Guide to the Mysteries of Harris Burdick." http://www.houghtonmifflinbooks.com/features/thepolarexpress/tg/mysteriesofharris.shtml
- "Forensic Sciences, a Crime Scene Investigation Unit" http://www.edu.gov.mb.ca/k12/cur/science/found/c_topics30s/forensics_unit.pdf
- "Paper Towel Chromatography." Zoom. http://pbskids.org/zoom/activities/sci/papertowelchromatogr.html
- Activities to Teach Portraiture to Elementary Kids | eHow.com http://www.ehow.com/info_7873389_activities-teach-portraiture-elementary-kids.html#ixzz2ABVtfCYC
- An Introduction to Urban Art - Drawing the Face Worksheet http://www.thebutchershop.com.au/.
- Deep Space Sparkle 3 Ingredient Art & Portrait Art http://www.deepspacesparkle.com/portrait-art-lessons-for-kids/
- eHow "Fifth Grade Science Projects About Fingerprinting." http://www.ehow.com/info_8594688_fifthgrade-science-projects-fingerprints.html
- How Stuff Works "History of Forensics" http://science.howstuffworks.com/forensic-lab-technique1.htm'
- Kids Science Challenge, "Learn the Secrets of Fingerprints." http://www.kidsciencechallenge.com/pdfs/2009activities/KSC_Fingerprint_2009.pdf
- ReadWriteThink.org "Mystery Cube" http://www.readwritethink.org/classroom-resources/student-interactives/mystery-cube-30059.html
- Science Kids http://www.sciencekids.co.nz/sciencefacts/forensicscience.html
- Simon, Cathy Allen. "The Mysteries of Harris Burdick: Using Illustrations to Guide Writing." ReadWriteThink.org http://www.readwritethink.org/classroom-resources/lesson-plans/mysteries-harris-burdick-using-30606.html
- STEMWorks http://www.stem-works.com/subjects/10-crime-scene-investigation/activities
- The Invisible Gorilla Experiment http://www.theinvisiblegorilla.com/videos.html
- The Science Spot http://sciencespot.net/Pages/classforsci.html
- "Fake Blood Recipes" http://www.stevespanglerscience.com/experiment/fake-blood-recipes
- "Crime Scene Investigation Student Activity." http://www.ehow.com/info_12038422_crime-scene-investigation-student-activity.html
- Defective Detective. An award winning film by Avner Geller and Stevie Lewis debuting exclusively in the the Cartoon Brew's 2nd Student Animation Festival. http://vimeo.com/25541923
- "Footprints." Crime Library. http://www.crimemuseum.org/library/forensics/footprints.html